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Area Boards

From personal experience we are aware that there is far too little recognition of either the work or the great potentiality of the endeavours of the Area Boards by either the employer or the employee. Because of its local vulnerability, the London and South-Eastern Area Board has been the most active and has acquired the most experience. The Board is constituted with a view to careful balance, having a membership consisting of three employers, three trade union officials, and representatives from the three Ministries concerned with aircraft production, naval construction and repair, and the needs of the army. The area officers for the Ministry of Aircraft Production, the Admiralty and the Ministry of Supply obviously have duties to their own departments, which may at times apparently conflict with one another, so that the Board is a proper venue for dispersing any differences. Labour problems are under the care of the divisional controller of the Ministry of Labour, and the export trade by a representative from the Board of Trade, both being members. The membership of the Board is reinforced by a liaison officer between it and the Industrial Capacity Committee, of which the Area Boards in the country are a part.

The Board has already largely sub-divided its work by the creation of nine clearing centres, seven in the London region and two in the South-Eastern area. The clearing centres, which are based on Ministry of Labour divisions, are detailed as to the officer in charge and his address elsewhere in this issue.

The work of the Board is extremely comprehensive. For instance, it is one of its duties to examine the results of the machine tool census which takes place at regular intervals. As there are some 4,000 engineering establishments within the area, this in itself is no light task. The object of this work is to find means of using spare capacity of tools and premises; to see that labour is used in the most productive way, and to make alternative arrangements, marrying industrial capacity to urgent requirements, consequent upon damage or disablement. Transport is a further subject to which attention is given, whilst the supply of precision tools as used by the various workers themselves is one often requiring urgent steps to be taken to minimise loss of production. The transfer of work or even the requisition of premises enters within the jurisdiction of the Area Board. Panels of employers and workers have been attached to the clearing centre areas, and the country is indeed indebted to those who have so willingly given their free services to work of such national importance. The Board has been charged, in certain eventualities, with the duty of acting directly under either or both regional commissioners for the two regions which the Board covers, such as in the event of severance from the central Government.

The Board is well aware of the importance of not disturbing production any more than may be essential. It would regret any tendency to denude firms of tools which might only momentarily be idle and which may be necessary immediately production becomes an important factor in order to maintain a correct balance of work. It appeals to everybody concerned for their active co-operation in making the clearing centres a model for the rest of the country, and generally to enhance the efficiency of the Area Board.

It should be noted that the emergency organisation service of the Ministry of Aircraft Production deals with first-aid to damaged buildings by securing roof covering and getting firms restarted at the earliest possible moment, as in the case of damaged service mains. For further reconstruction the Board will assist, whilst avoiding duplication of work by other departments, by working in the closest co-operation with them.

Finally, it is worth stressing that concerns which have contacted with the Board are appreciative of the services rendered, for it is no committee for debating purposes but is a live executive organisation devised to help both employers and workers.

Electroplated Alloy Coatings

Electroplated alloy coatings in a variety of colours for many applications are in large daily production in American industry, and therefore can no longer be termed laboratory curiosities, according to Dr. Charles L. Faust, research engineer of Battelle Memorial Institute, who addressed the recent seventy-eighth general meeting of the Electrochemical Society, meeting in Ottawa.

Although a method for the electrodeposition of brass, an alloy of copper and zinc, was discovered nearly 100 years ago, only in very recent years have other alloy coatings begun to replace or supplement electroplated coatings of single metals, as chromium, nickel, silver, gold, copper, and others. That the electroplating industry is a vast one is evidenced by the fact that the automobile industry alone used 3,500 tons of electrodeposited coatings in a recent year.

Alloy deposition is considered as any process where two or more metals are deposited simultaneously and in which, due to this co-deposition, special properties are imparted to the electroplate. In general, alloy deposits are denser, harder, and brighter than plates of single metals, Dr. Faust pointed out. There are certain composition ranges where alloy deposits have been found more corrosion resistant, more adherent to the basis metal, more readily buffed, more suitable for subsequent plates, more readily deposited over a wider range of operating conditions than one or both of the individual metals.

Alloys for Deposition

Processes for the deposition of brass, bright metals, bronze, black molybdenum, black nickel, and carat gold are generally known. Carat gold is used widely on jewellery and is available as the well-known green, white, or yellow golds.

An excellent example of adapting alloy deposition to an engineering problem is found in the use of brass plating to ensure rubber adhesion to steel. Most of the fast-curing, commercial rubber stock will adhere to so-called alpha-brass, but in general not to other metals and alloys. The process has been in operation for a number of years in the rubber industry for making rubber-lined steel acid tanks and other rubber-coated metal products.

Many of the bearing alloys used in the motor vehicle industries are electroplated on strong steel backs. These include such combinations as cadmium-silver and silver-lead. According to Dr. Faust, the silver-lead bearing alloy, a development of the Battelle laboratories, is especially suited for aircraft engine use, and probably will see wide use in that field.—Extracted from "The Iron Age."

New German Iron and Steel Merger

A new corporation, Eisen und Hüttenwerke Köln A.G., has been formed in western Germany by the fusion of a number of concerns with an aggregate steel output of 2,700,000 tons per annum. The merged companies include the Rasselsteiner Eisenwerksgesellschaft, Eisen und Hüttenwerke Bochum, Eisenhüttenwerke Thale and various small concerns. In addition, the corporation holds a majority interest in the Neunkirchen Eisenwerke, the principal iron and steel concern in the Saar.

Photoelectric Width Gauge

A photoelectric width gauge for application to strip mills was exhibited by the General Electric Company, Schenectady, N.Y., at the Iron and Steel Engineers' Convention in Chicago, Ill., last month. The gauge has been developed primarily for use on hot-strip mills, but can be used on cold mills as well. It measures the width of strip moving at speeds as high as 2,000 ft. per min. or faster. Its outstanding advantage lies in the fact that operators can observe the accuracy to which they hold the strip width and are permitted to correct immediately any deviation from the required value.

Some Jobbing Foundry Experiences—XII

By "TRAMP"

Various types of wheel castings are occasionally required to fit on to an existing line shaft without dismantling the other wheels, etc., to accomplish this. Consequently the wheel must be made in halves and bolted in position through suitable arms or ribs. Fig. 1 is a sketch of a medium-size mitre wheel. The right-hand half shows it as when made solid with six arms or ribs, while the left-hand portion shows the centre ribs enlarged to accommodate a bolt. Very rarely are patterns made for half wheels, but the following expedient is adopted. Assuming that a pair of mitre wheels are required, one whole and the other in halves, the pattern is made for the whole one. This is then moulded and cast. Two pieces are next made to form the arms carrying the boss. These are made thicker than the original ribs and of shape

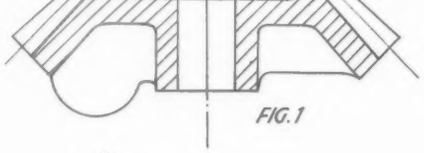

FIG. 1

FIG. 2

similar to the left-hand half of the sketch, and are fitted over two ribs through one centre line, which occurs at the centre of a tooth space and the pattern as moulded. A template having been prepared of the shape of the section through these ribs, as shown in Fig. 2, two pieces of thin sheet metal are prepared from this which will be subsequently placed in the mould to split the casting in halves. The pieces being cut, one side is oiled and coated with blacking, while the other side is not treated. The object is for the metal to burn into one side and fail to adhere to the other, thus enabling the wheel to be separated into two pieces and yet retain its true shape on reassembly. After two bolt holes have been drilled through the casting, it is ready for use.

A Bronze for Worm Gearing

A heat-treatable nickel-tin bronze developed by the International Nickel Company and possessing a number of characteristics making it a suitable alloy for worm gearing, was described in a Paper presented to the American Gear Manufacturers' Association by B. A. MILLER. One such alloy which has proved to have good foundry characteristics, strength properties and moderate cost is made up of 5 per cent. tin, 5 per cent. nickel, less than 0.01 per cent. lead, up to about 2 per cent. zinc, and the balance copper. In the as-cast condition, this alloy has a tensile strength of 22 tons per sq. in. and 44 per cent. elongation in 2 in.

When heat-treated the bronze develops even higher physical properties. The heat-treatment comprises a solution treatment or homogenising anneal at elevated temperatures which leaves the metal, after quenching, in a dead soft condition; then follows an ageing treatment at 260 to 315 deg. C. for several hours, which causes the alloy to harden. Tensile strength may be thus increased to 36 tons and even higher.

Random Shots

"The Iron Age," "Marksman" notes, has been pulling Mr. Roosevelt up for pronouncing "decadent" as we do and as he thinks it ought to be pronounced. It is quite possible, however, that Mr. Roosevelt was only taking a leaf out of Mr. Churchill's book, for he careth not for any dictionary or the precedent of general usage when it comes to pronunciation. On that matter he is a law unto himself, but over here he is loved for his little idiosyncracy of speech as much as for his own special taste in funny hats. His many references to Monte Video during a certain well-remembered incident in this war were a delight to listen to, for one could not help feeling that he enjoyed his own little joke of pronouncing that name in a way that no one else would think of. Many people are anxiously waiting for the R.A.F. to get busy over Caen in order to hear what he will make of that. It is a name over which there is so much confusion here that one suspects that the R.A.F. have only refrained from bombing the town because the B.B.C. can't decide how they would announce it!

* * *

The same writer in our American contemporary, still discussing pronunciation, this time of the name of a town, refers to having read "Lady Chatterly's Lover," by T. E. Lawrence. One can only hope that, having read all about that lady's one (and only?) lover, he now feels as wise as one (just one) "Pillar of Wisdom"!

* * *

An original note was introduced into the last annual dinner of the American Gear Association by engaging, unbeknown to the diners, a professional entertainer as the guest speaker. He called himself Dr. Charles Bartholomew, S.O.O.M.B., President of the Liverpool Board of Trade, and led his audience to believe for a time that he was a pucka Englishman giving an Englishman's impressions of America. The S.O.O.M.B. was apparently meant as a skit on the British predilection for titles and decorations, for it turned out only to mean Son of Old Man Bartholomew. British papers please copy, commands the recorder of the speech. Well, one British paper has duly copied, but fails to see why it should. On the other hand, British organisers of dinners might well note the obvious advantages of a professional entertainer as a guest speaker here and there!

* * *

The Institution of Mechanical Engineers has just published a reproduction in colour of its newly-granted armorial bearings. A description is also given in that deliciously cryptic language peculiar to and understood only by the College of Arms. It abounds with such phrases as "a grey horse forcene proper gorged with a Coronet composed of four Fleurs-de-Lys with Chain reflexed over the back . . ." The design, to "Marksman's" way of thinking, is not much more inspiring than the one belonging to the Institute of British Foundrymen, which depicts Science hand in hand with Labour, and about which he often feels that it would have been more appropriate to depict as supporters a patternmaker dormant and a machine shop foreman rampant.

* * *

The week's worst crossword clue comes from the "Daily Telegraph":—

Clue.—A mouldy job for founders.

Answer.—Cast iron.

The layman, as usual, shows his ignorance of foundry matters, for the answer should have been "iron castings."

"MARKSMAN."

Vanadium in Cast Iron

By E. PIWOWARSKY

(*Translated from "Die Giesserei."*)

Equilibrium Diagram and Influence on Structure

The element vanadium has a specific gravity of 5.7 and melts at 1,715 deg. C. The equilibrium diagram for the iron-vanadium binary system established by R. Vogel and G. Tammann,[1] F. Wever and Jellinghaus and others, resembles very closely that of the iron-chromium binary system. The minimum in the melting-point curve at the continuous series of solid solutions lies at 1,435 deg. C. and about 32 per cent. V. The constriction of the γ region is effected by vanadium contents which, according to the work of a number of investigators, lie between 1.1 and 2.5 per cent. V (more probably the limiting values are 1.1 and 1.5 per cent.)[2].

The carbides V_2C, V_3C_2, V_4C_3, V_5C_4 and V_8C have been prepared synthetically by various investigators, but apparently only the carbides V_8C and V_4C_3 are stable in the binary system.[1] Recently, E. J. Maurer, T. Döring and W. Palewka[17] have separated the carbides from various vanadium steels, the formulæ VC and V_4C_3 having been found chemically. Specimens of vanadium carbide, of the same composition, have been prepared synthetically. The latter

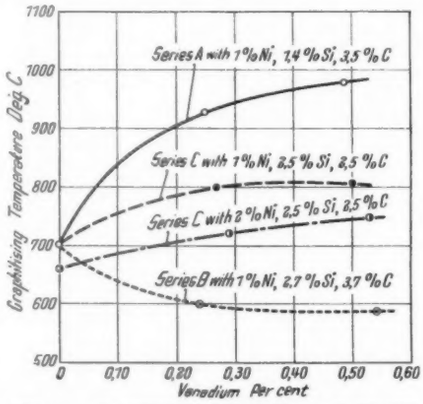
Series A with 1 % Ni, 1,4 % Si, 3,5 % C
Series C with 1 % Ni, 2,5 % Si, 2,5 % C
Series C with 2 % Ni, 2,5 % Si, 2,5 % C
Series B with 1 % Ni, 2,7 % Si, 3,7 % C
Graphitising Temperature Deg. C
Vanadium Per cent

FIG. 1.—INFLUENCE OF VANADIUM ON GRAPHITISATION TEMPERATURE OF CAST IRON CONTAINING NICKEL. (CHALLANSONNET.)

and the specimens of carbide from steel have been subjected to X-ray examination, and within the accuracy of measurement (method of calibration) all the specimens were found to have the same face-centred cubic lattice with a length of side $a = 4.152 \pm 0.005$ Å. This agrees with earlier investigations by A. Morette[3] who, by melting together V_2O_5 and sugar carbon, obtained a carbide approaching the formula V_4C_3 with $a = 4.146$ Å.

This discovery does not, however, preclude the existence of a vanadium carbide VC containing more carbon. On the contrary, it appears that between V_4C_3 and VC there is a mixed series in which the carbon atoms prefer certain lattice positions only, and are unable to occupy all the possible positions. Only the carbide VC is to be regarded as having a saturated lattice.[17] The special carbide to be expected in commercial steel and iron containing up to 0.5 per cent. V will chiefly be of the formula V_4C_3, regarding which, however, it is not yet known definitely whether it occurs also as a complex carbide with the cementite.[1] In the quasi-binary system Fe_3C and V_4C_3, which is a simple V-shaped diagram having a eutectic at 1,151 deg. C., R. Vogel and E. Martin,[26] contrary to M. Oya,[24] assume that the carbides are not mutually soluble.[1] V_4C_3 is more stable than carbides of chromium and tungsten, takes up carbon from the matrix and, in consequence of its solubility in austenite, even though this solubility is slight and slow, is the reason why material containing vanadium often possesses relatively slight hardening properties, even after elevated heating temperatures.

It is true that this phenomenon could also be ascribed to the fact that the proportion of hardening carbon is diminished by the combination of a proportion of carbon corresponding to the amount of added vanadium. H. Schrader and F. Brühl[4] have indeed found that in the case of manganese-vanadium steel, the effect of the combining of carbon to form sparingly soluble carbides could not be eliminated even by increased quenching temperatures at which distortion on quenching was still permissible. According to J. Challansonnet,[5] in the case of cast iron also, vanadium scarcely diminishes the critical cooling rate during martensitic hardening, unlike chromium, molybdenum, and other elements. Additions of 0.25 to 0.50 per cent. V appeared, however, to raise the temperature of pearlitic solution by about 100 deg. C. without affecting the position of the pearlitic interval on cooling from high temperatures. The addition of 0.25 per cent. V to melts on a basis of the composition according to A in Table III which, unalloyed, began to graphitise

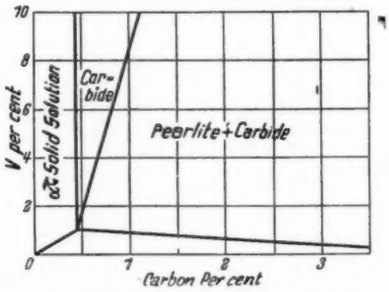

FIG. 2.—EQUILIBRIUM DIAGRAM OF IRON-CARBON-VANADIUM ALLOYS. (VOGEL AND MARTIN.)

at 835 deg. C., raised the graphitisation temperature by 95 deg. to 925 deg. C., while the addition of 0.50 per cent. V raised the temperature even to 975 deg. C. Similar effects were found in the case of additions of vanadium to unalloyed melts on the basis of B and C in Table III.

In corresponding melts containing nickel (Fig. 1), the same effect was observed, except for the melt of series B with 1 per cent. Ni, which, in view of the high silicon and carbon contents, began to graphitise earlier with increased vanadium content (seeding effect of the vanadium carbides). The Curie point of the cementite was lowered 160 and 130 deg. by 0.25 and 0.50 per cent. V respectively. In the vanadium-silicon system, H. J. Wallbaum[6] found the compound V_3Si. It crystallises in the β-tungsten type with a length of side $a = 4.712 \pm 0.003$. V_3Si is isomorphous with the compound Cr_3Si ($a = 4.555$ Å).

The structure of cast iron is sometimes appreciably refined by additions of vanadium, the vanadium-rich carbide tending to the spherical form, unlike lamellar pearlite. In view of the great affinity of vanadium for carbon, free iron carbide only occurs when the larger part of the vanadium has been saturated to form V_4C_3 (see Fig. 2). With 2 per cent. V, for instance, iron carbide occurs in the structure only above 0.4 per cent. C. On the whole, conditions in the iron-carbon-vanadium system can be summed up most simply, in the light of modern knowledge of the particular systems coming into consideration, by stating that the added vanadium forms a stable vanadium carbide V_4C_3, which is practically insoluble in solid iron. The system can then be traced back to the conditions in the binary iron-carbon system, the characteristic saturation points of the eutectic, solid solutions, pearlite point and so forth, in concentration and temperature position, being dependent on the carbon content remaining after the deduction of the carbon content required for combining with vanadium to form V_4C_3.

Thus, whereas in the iron-carbon-chromium system, higher chromium contents are required for constricting the γ region, the higher the carbon content of the alloy, whilst the stability area of the γ region is constricted at the same time and finally disappears, the addition of vanadium merely results in a calculable parallel

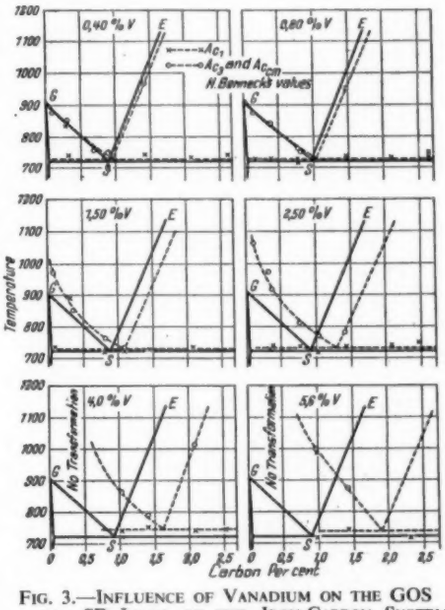

FIG. 3.—INFLUENCE OF VANADIUM ON THE GOS AND SE LINES OF THE IRON-CARBON SYSTEM. (HOUGARDY.)

displacement to the right (Fig. 3) of the iron-carbon diagram, such as has never been observed before with any other element. Since, according to the formula V_4C_3, 0.175 per cent. C is combined for 1 per cent. V, the conditions can be readily obtained by calculation. The fact that this calculation is generally correct[25] confirms the views of E. Maurer and of R. Vogel and E. Martin, according to whom the carbide V_4C_3 is predominant in the iron-carbon-vanadium system.[25]

If, notwithstanding, the addition of vanadium to steel and cast iron produces a marked alteration in the pearlitic structure (tendency to fine sorbitic structure), this may in the first place be connected with the deoxidising effect of vanadium, or with the seeding effect of the numerous finely-divided vanadium carbides, and in the second place with the possible existence of even a slight mutual solubility of the two carbides (iron carbide and vanadium carbide). Since it may be assumed that the major portion of the vanadium carbide separates out even in the molten mass, it may be expected that this carbide separation will have an appreciable effect on the undercooling of the eutectic, which would appear to indicate the especial value of vanadium as a ladle addition to low-carbon

cast iron for preventing graphite formation, on the assumption that vanadium carbides exert a seeding action in the solidifying cast iron by virtue of their structure, melting point and free surface energy, this being probable according to Fig. 4, reproduced from F. Roll.[28] Even the slight mutual solubility of the carbides in the solid state would provide an explanation of the influence of vanadium on the properties which are due to an increase in the stability of the iron carbide by the vanadium (resistance to heat, constancy of volume, strength at high temperatures and so forth). In ferrite and austenite, however, vanadium will only be detectable when its content is higher than that corresponding to the carbide V_4C_3.

Influence of Vanadium on the Hardness and Strength of Cast Iron

Contrary to O. Smalley,[7] who previously disputed the hardening effect of vanadium, the author was able to show, even with reference to earlier experiments,[8] that vanadium promotes the formation of carbide to a considerable extent. These experiments dating from 1925 were made with relatively high-carbon

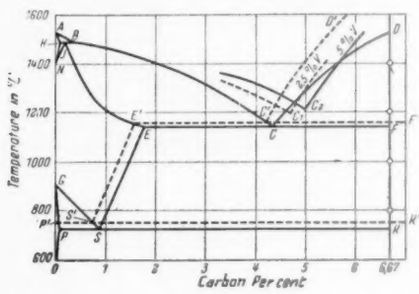

FIG. 4.—DISPLACEMENT OF C POINT BY VANADIUM. (ROLL.)

verse strength attained a value of 52 kg. per sq. mm. on testing with the casting skin appears to show that vanadium exerts a very favourable influence on the toughness, manifest in Table I by a considerable increase in the specific impact energy. This observation agrees with the results of R. Moldenke[9] and others, who found a substantial increase in density and resistance to wear, due to the hardening effect of vanadium on the casting. The experiments* thus appear to indicate that the application of vanadium will be successful in the case of castings which have to possess high resistance to impact, high mechanical properties and high resistance to wear. The experiments also lead one to presume that vanadium ought to be a valuable element in the production of chilled castings."

These early observations by the author on the increase in the carbide promoting influence

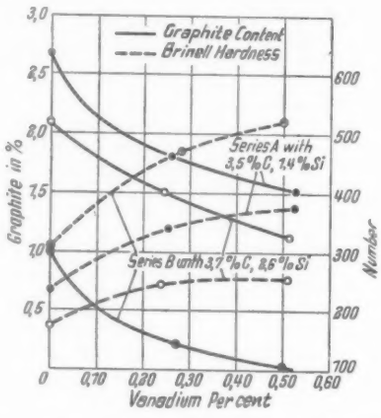

FIG. 5.—INFLUENCE OF ADDITION OF VANADIUM ON THE QUANTITY OF GRAPHITE AND HARDNESS OF CAST IRON. (CHALLANSONNET.)

TABLE I.—*Experiments with Vanadium.*

Series.	T.C. Per cent.	C.C. Per cent.	Gr. Per cent.	Gr. as per-centage of C.C.	Si. Per cent.	V. Per cent.	Trans-verse strength. Kg. per sq. mm.	Deflec-tion. Mm.	Com-pression strength. Kg. per sq. mm.	Specific impact energy. Mkg. per sq. cm.	Brinell hard-ness.
I	3.95	1.51	2.44	61.7	1.14	—	33.0	5.5	81	0.40	170
	3.95	1.58	2.43	60.5	0.99	0.25	34.5	5.5	104	0.42	201
	3.90	1.45	1.45	37.2	0.95	0.45	39.0	4.8	113	0.42	258
	3.85	2.50	1.35	35.5	0.95	0.65	*41.0*	4.5	122	0.57	*305*
	3.90	3.84	0.06	1.23	0.95	1.05	*50.0*	4.0	155	0.59	*436*
II	3.90	1.22	2.76	70.0	1.50	—	31.0	6.6	79	0.33	170
	4.00	1.25	2.75	60.7	1.55	0.20	32.0	6.5	87	0.33	190
	4.00	1.28	2.72	60.2	1.66	0.45	35.0	6.8	112	0.38	195
	3.95	1.67	2.28	58.5	1.65	0.75	*46.0*	7.0	122	0.41	*242*
	3.95	1.72	2.23	56.7	1.70	0.95	*52.0*	6.5	134	0.59	*277*
III	3.90	0.95	2.95	76.0	2.71	—	27.0	7.6	78	0.28	160
	3.85	0.95	2.90	74.3	2.85	0.43	27.5	7.4	81	0.34	175
	3.85	1.16	2.69	70.0	2.82	0.70	29.5	6.5	108	0.41	220
	3.80	1.28	2.52	66.5	2.85	0.95	31.0	6.1	115	0.42	242

irons and are therefore of paramount importance in connection with the production of chilled alloy cast iron. With reference to the results collected in Table I, the author said at the time:—

"It is remarkable that the influence of vanadium first makes its appearance with additions over 0.5 per cent. and then very suddenly, the effect in the lower silicon series I and II being less pronounced than in the series III, with 2.75 per cent. Si. The hardening effect of vanadium appears in a very rapid increase in hardness and in the compressive strength. The transverse strength likewise attains relatively high values (see the values in italics in Table I). Of course, iron having such a high carbide carbon content, as most of the melts of series I and II, can no longer be used as commercial cast iron, but the fact that, despite such unusual increase in hardness, the transverse strength of vanadium at contents above about 0.5 per cent. agree with more recent results of J. Challansonnet,[10] who has found in an iron with 3.8 C; 2.4 Si; 1.4 Mn; 0.03 S; and 0.07 per cent. P, an influence of the vanadium on the carbide formation and hardness as shown in Fig. 5, the transverse strength and shear strength varying according to Table II.

Melts on the carbon and silicon basis shown in Table III according to J. Challansonnet were made more rapidly white by the addition of vanadium, the lower the carbon or silicon content of the melt (Table IV).

* In the experiments on the influence of vanadium, the test-bars were cast by mistake at 1,200 to 1,250 deg. C., so that the formation of carbide was perhaps additionally promoted by the excessively low casting temperature. This, however, hardly affected in any way the characterising features of the addition of vanadium, but, on the contrary, merely resulted in a parallel displacement of the values found to somewhat higher carbide carbon contents, with a corresponding displacement in the mechanical values. In any case, the figures are comparable among themselves.

TABLE II.—(J. Challansonnet.)

V. Per cent.	Hardness. Kg. per sq. mm.	Transverse strength (Fremont). Kg.	Shear strength. Kg. per sq. mm.
0.0	150	450	26
0.10	180	560	31
0.20	190	650	34
0.45	225	900	45
0.60	270	1,050	51.3
0.75	320	Solidified completely white	—
1.10	503		

TABLE III.—(J. Challansonnet.)

Melt.	C. Per cent.	Si. Per cent.	Mn. Per cent.	P. Per cent.	S. Per cent.
A	3.55	1.46	0.42	0.077	0.022
B	3.70	2.70	0.56	0.110	0.040
C	2.50	2.50	0.55	0.070	0.038

TABLE IV.—(J. Challansonnet.)

Melt.	V. Per cent.	Hardness (Brinell).	Total carbon. Per cent.	Carbide carbon. Per cent.
1 A	0.00	228	3.52	1.40
8 A	0.24	342	3.50	2.05
9 A	0.52	371	3.52	2.35
1 B	0.00	178	3.71	1.05
8 B	0.26	241	3.70	1.90
9 B	0.57	253	3.65	2.10
1 C	0.00	301	2.50	1.50
8 C	0.28	471	2.42	2.20
9 C	0.59	512	2.35	2.30

TABLE V.—*Graphitisation Values of Different Elements.*

Element.	Graphitisation value.
Si	+ 1.00
Al	+ 0.50[1]
Ti	+ 0.40[2]
Ni	+ 0.35
Cu	+ 0.20[3]
Mn	− 0.25[4]
Mo	− 0.30[5]
Cr	− 1.00
V	− 2.50[6]

[1] This figure holds up to about 2 per cent. Al. Above this, up to about 4 per cent. Al, the graphitisation value gradually decreases until the graphite disappears completely.

[2] Mean value. Small quantities of Ti of 0.1 to 0.2 per cent. have a stronger action than Si on the graphite formation, while further quantities have a lesser effect than Si.

[3] The value falls to 0.05 in the case of carbon contents of about 3 per cent. and over.

[4] For Mn contents between 0.8 and 1.5 per cent. Below 0.8 per cent. Mn has a weaker effect on carbide formation, and may even have a strong graphite-forming influence below 0.6 per cent. in the presence of S.

[5] For Mo contents between 0.8 and 1.5 per cent. Below this range Mo has a weaker action on graphite-formation, while above it has a stronger action.

[6] Mean value.

According to Table V, the relative graphitisation value of vanadium, taking that of silicon to be +1, would appear to be about −1 for carbon + silicon contents between 5 and 6, and about −2 to −3 for carbon + silicon contents from about 4.5 and below, *i.e.*, the action of vanadium on the carbide formation is stronger, the greater the tendency of the iron *per se* to mottled or white solidification. The effect of vanadium is most pronounced in iron with less than about 1 to 1.5 per cent. Si.

(To be continued.)

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Preventing Cooling Water Corrosion

By F. J. MATTHEWS, B.Sc.

Adequate and suitable supplies of cooling water are vital to the satisfactory operation of compressors, oil engines and similar machinery. Corrosive attack by impurities in the cooling water may become an even more serious problem than scale deposition on the cooling surfaces, since the engine may suffer great damage before the trouble is detected. Whereas with scale deposition a chipping operation or other process will at any rate remove the scale and leave the machine but little changed, corrosive attack may seriously weaken the unit. Measures for prevention of corrosion are therefore extremely desirable.

Even the filling of tanks, etc., in the cooling system with a soft coolant such as rain water, so that this soft water circulates over and over again through the jackets, will not necessarily avoid corrosion dangers. Most soft waters contain corrosive elements which will cause extensive damage to equipment in the course of prolonged service. It should not be assumed that a slight corrosive power on the part of a water supply will be eliminated after a slight amount of initial corrosion. A small amount of initial corrosion does not "neutralise" a water and leave it harmless, so that one cannot be prepared to tolerate slight initial corrosion for the sake of subsequent safe service.

It is a fact that extensive corrosion can and does proceed in many instances from very small quantities of corrosive impurities in the water supply, the total amount of wasting frequently being out of all proportion to the amount of corrosive present. In addition, water will be lost from most cooling systems as a result of evaporation, leakage, etc., and fresh corrosives are likely to be introduced to the system in the make-up water. It is clear, therefore, that no reliance should be placed upon soft waters from natural sources, but effective measures should be taken to protect equipment from the risks of such cooling waters.

Nature of Corrosion

Corrosion is commonly thought of in terms of acid attack, though there are other forms of dangerous corrosion. An important point should be emphasised in connection with acidic corrosion. The corroding action of the acid may be repeated again and again, since the iron compounds formed by the interaction of acids and iron are unstable and tend to decompose when their aqueous solutions are exposed to heat. In this decomposition, the acid is set free again and an iron oxide is formed, the latter sometimes forming visible evidence of the rusting or corrosion which has taken place. It follows from this that further corrosion may take place through the medium of the regenerated acid, and the cycle outlined may be repeated over and over again—in fact, as long as the contaminated water is in service and exposed to conditions favouring the reactions concerned.

Acidity in the water may also arise as a result of decomposition of certain minerals such as magnesium chloride, which form part of the permanent hardness found in most water supplies. Magnesium chloride, for example, when heated in aqueous solution, breaks down to the free hydrochloric acid and magnesium oxide or hydroxide. The free acid, of course, attacks the iron of the engine or other equipment, and produces iron chloride, which in turn reverts to rust as mentioned above. The acid is therefore regenerated at the end of this cycle, and is able to set up further corrosive attacks, which continue indefinitely.

Increased Temperature Favours Attack

The decomposition of the iron salts, and also of impurities such as magnesium chloride, magnesium nitrate, calcium chloride, etc., is favoured by increased temperatures. The higher the temperature of the water, the greater the extent to which the corrosion products or unstable minerals are broken down to regenerate free acids. Ideal conditions favouring such decomposition are found in steam boilers, but one should not forget that this repeat action means that quite insignificant quantities of acid will cause serious damage. In other words, it is not necessary to have extensive decomposition of the minerals and compounds concerned before appreciable corrosion can continue indefinitely. This should be borne in mind particularly in recirculating systems, where the cooling water is used over and over again by thermosyphonic action or after passage through mechanical film coolers, etc. Under such conditions, acid contamination of the coolant is likely to increase gradually, since the minerals are exposed repeatedly to heating. Although the temperatures may be fairly moderate, progressive decomposition of the minerals will take place.

Natural water supplies may become contaminated with acidity in various ways. Rain water dissolves acid gases from the atmosphere, particularly the sulphur gases from smoky atmospheres over cities; nitric acid gases are also found in the air after thunderstorms and may be extracted in rain falling at the time. Canals and other waterways may be contaminated with waters pumped from pits and mines, and the water from such workings is usually strongly acid in character. Fertilisers put down on adjoining land have also caused acidity in the water of streams. Even the vegetation may decay and produce acids, corrosion of plant having been traced in some instances to the presence of "peaty" and other acids in the water supply. These remarks refer to free acids. In addition, most waters contain permanent hardness minerals, and such minerals may include unstable potential corrosives as well as scale-forming constituents. A water containing magnesium in particular is to be regarded with strong suspicion.

Alkali Additions

Fortunately, it is quite simple to avoid dangers from acidity, whether existing in the free state in the water or liable to result from unstable minerals. The addition of alkali to the water will neutralise any free acidity, but some excess over this amount should be allowed in dosage to leave residual alkalinity in the water to neutralise any future possible development of free acidity, such as by decomposition of magnesium chloride or other unstable minerals. Periodically, the condition of the water may be checked for suitable alkalinity by means of a litmus paper test. Small books of litmus paper may be obtained from any chemist. A red paper dipped in the water should turn a deep blue if the water is definitely alkaline. A more complete test is to titrate the water with standard acid as detailed in water treatment books for determination of alkalinity. This will indicate the extent to which the alkalinity is due to sodium carbonate and how much is due to caustic alkali; the latter is useful for taking up carbon dioxide gas, which causes corrosion in some circumstances.

Dissolved Gases

Corrosion may also arise due to the presence of dissolved gases in the cooling water. These undesirable gases are carbon dioxide and oxygen. The carbon dioxide attacks iron in some circumstances, forming iron carbonate, which decomposes upon exposure to even moderate heat, producing rust and carbon dioxide gas again. Corrosive attack in this instance thus shows the characteristic repeat action outlined above. Caustic alkali will absorb this gas and eliminate the trouble; sodium carbonate will also take up the gas, but on exposure to heat the bicarbonate formed is likely to release the gas again, so that little improvement may be effected as a result of this latter treatment.

The explanation of corrosion due to dissolved oxygen which is commonly accepted is that it causes the initiation of electrochemical action as follows. Normally, it is supposed to form a protective oxide film over the surface of the metal. It has been shown experimentally that if a part of the metal is not exposed to the dissolved oxygen, then an electrolytic cell is set up between such metal and that part which is exposed to dissolved oxygen. Electrochemical corrosion is then set up, those parts of the metal not protected by oxide film being dissolved or corroded just like one of the poles in an electric accumulator. This type of corrosion may therefore result at a pore or crevice in the metal, under a patch of scale, due to defects in water circulation, etc. Pitting of the metal is caused by preliminary corrosion at some crevice or other spot not reached by oxygen, and the deeper the pit penetrates, the more severe the corrosion, since there is less and less likelihood of the oxygen penetrating to the metal. Even the corrosion product—rust—may increase the severity of the corrosion by remaining in the locality of the attack instead of dispersing throughout the body of the water. Local features, such as details of individual mineral impurities in the water, influence this aspect, however, and may call for special preventive measures.

Specific Remedies

Corrosion by dissolved oxygen is fortunately greatly reduced when the water is maintained definitely alkaline, but complete prevention may require the absorption of the oxygen or the addition of an inhibitor to the water. Tannin extracts can be used to absorb the dissolved oxygen chemically; the exact amount of dosage required cannot be stated, since the efficiency of absorption varies according to the bark, root, etc., which has been used in preparing the extract. Chemicals such as sodium sulphite or bisulphite may also be used for absorption and neutralisation of the dissolved oxygen; the amount of sulphite required is about 16 lbs. per million gallons of water for each 1 ml. per litre of dissolved oxygen—normally water holds up to 8 to 9 ml. dissolved oxygen per litre of water.

The chemical absorption of dissolved oxygen will be economical for closed recirculating systems rather than where the water is passed once through the equipment. Even on closed systems, however, it is necessary to minimise access of the water to the air, since oxygen will be readily absorbed from the atmosphere. Therefore, where the water passes once through the cooling system to waste, or where mechanical coolers are incorporated in a cooling circuit and the water is film-cooled by exposure to air draft, chemical absorption may not be permissible. Under such conditions, dissolved oxygen corrosion can be combated by adding sodium dichromate to the water, dosage being up to 5 lbs. of mineral per 1,000 galls. of water, according to local characteristics such as mineral content of the water. The dichromate gives protection by forming a corrosion-resistant film on the metal surface. Sodium silicate should not be used as an inhibitor of

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Die-Castings for Commercial Motor-Vehicle Construction

The advantages accruing from the use of aluminium-alloy die-castings for components of commercial vehicles are emphasised in an article published recently in "The Commercial Motor." The process enables an accurate and practically finished article to be produced at a low cost, whilst machining costs and the quantity of material reduced to scrap are minimised. Where the mass production of a given component is desirable, die-casting enables bulk delivery to be maintained, without entailing the employment of an undue amount of expensive skilled labour. It is, indeed, in the field of mass production that the process may best be employed, because the cost of the die is thereby distributed over a large number of articles. For example, a tool-room cost of £30 incurred in the production of a die will represent a charge of 6s. per die-casting when the total output is 100 components, but only 1.2d. per die-casting when 6,000 articles are required.

Consequently, an essential first step in deciding whether gravity die-casting is suitable for the production of a given component is to consider whether or not the number required be sufficient to justify the cost of the necessary die. Generally speaking, articles required in batches of 1,000 or more per annum will be found to justify die-casting. This number may be considerably reduced, however, in special cases where the design of a component is such that expensive and difficult machining would be necessary were older methods of casting employed.

A Widely-Used High-Silicon Alloy

For components such as radiator and water-pump parts, covers, sumps, gearboxes and various types of housings and manifolds, an alloy of high-silicon type, to B.S.S. L.33, has been widely used for a considerable time. The material possesses an excellent combination of good casting characteristics, resistance to corrosion, ductility and high impact strength. It is of the non-heat-treatable type, but where maximum mechanical properties are required, it must be subjected to a special modification process, which produces a refinement of the eutectic structure. A heat-treatable type, with still higher tensile properties, is also used, but is, naturally, somewhat more expensive.

Aluminium-copper alloys, to specification B.S.S. I.8, are also suitable for gravity die-castings, whilst for pistons, alloys of the high-silicon type and more complex alloys, such as the well-known "Y" alloy, are largely employed. The high-silicon alloys are of special importance, in that they combine low expansion characteristics with high mechanical properties at elevated temperatures. They are, therefore, peculiarly suitable for piston construction.

A well-known alloy of this type, the Lo-Ex alloy, is employed in the form of gravity die-cast pistons in practically all types of internal-combustion engines, including compression-ignition units using pistons of diameter up to 20 in. The alloy, in addition to the properties already mentioned, has excellent bearing qualities, and can be satisfactorily treated by the anodic oxidation process, a property not generally possessed by other widely-used piston alloys. Pistons of Lo-Ex alloy are, therefore, highly resistant to corrosion, and the capacity of the anodic film for absorbing lubricants (including colloidal graphite) enables a lubricant film, applied immediately after anodising, to be retained throughout the working life of the piston, provided that the latter is not subjected to abnormally severe abrasion.

Weight Reduction a Factor

It has, however, been recognised for some time that a need exists for extending the application of the gravity die-casting process to the production of commercial-vehicle structural components subjected to more or less severe stresses in service. In all such vehicles it is desirable that weight be kept to a minimum, this applying particularly to the 50-cwt. category. The use of high-strength light alloys has already been exploited by one leading chassis maker with this end in view.

The higher cost of the material is, to some extent, offset by reduced machining costs, whilst the weight saved can be usefully employed in one or more of several directions—in improving engine power and increasing engine size, in employing a more generous size of clutch, a more robust body, or a larger tyre section, etc. The problem of using the high-strength alloys has, however, not been an easy one to solve, because, as a general rule, alloys with the necessary mechanical properties do not possess the foundry characteristics suitable for die-casting.

A Versatile Alloy Developed

The design problems involved also present some difficulty, as they are concerned with requirements not only regarding ultimate tensile strength, but also with stiffness combined with ease of assembly and a capacity for dealing with momentary excess loadings. Thus, a guaranteed elongation figure, which is not a property usually possessed by the stronger casting alloys of aluminium, becomes essential.

As a result of intensive development work, however, it has been found possible to embody in a single casting alloy the properties desired, namely, a high proof stress allied to a guaranteed elongation and the ability to produce relatively complicated components by gravity die-casting.

The alloy is of the heat-treatable type and contains 4 to 5 per cent. copper, with silicon, iron and titanium restricted to maximum percentages of 0.9, 0.7 and 0.25 respectively, and additional impurities limited to a maximum of 0.2 per cent. By varying the heat-treatment, a wide range of mechanical properties becomes possible, the proof stress ranging from 24 tons down to 12 tons per sq. in. and the elongation (on 2 in.) ranging from 1.5 to 15 per cent. As a result of this wide range of properties three Air Ministry specifications, D.T.D. 361, D.T.D. 304 and D.T.D. 298, have been drawn up to cover the material.

The material is capable of meeting a wide range of requirements regarding strength, stiffness and resistance to impact and shock. Its machining qualities are excellent, and its good natural resistance to corrosion can, if necessary, be further improved by anodising.

Thus, in the form of gravity die-castings, the material has found ready employment, particularly in aircraft and motor-vehicle construction. for stressed parts for which wrought alloys had formerly been used. As a result considerable amounts of expensive machining to shape for hole bosses and the making of attachments are avoided, because such features may be incorporated on the casting itself.

Structures built up from sheet and extrusions, involving high tool and fabricating costs, are also being substituted by die-castings in the material. A further development is the adoption of aluminium for purposes for which, owing to the high machining costs involved in the use of wrought-aluminium alloys, steels had formerly been used.

The wide avenues open to the alloy in the field of commercial-vehicle construction can, therefore, readily be visualised. Examples of applications already developed include operating levers, brackets, universal-joint housings, engine bearers and pump impellers. Wheel and bearing parts of vehicle chain-track mechanism, oscillating links and levers, and other parts of mechanised agricultural equipment are also striking uses. With the removal of the present restrictions on the use of aluminium, the material will be applied to a considerable additional number of important structural components for which exhaustive tests have proved it to be eminently suitable.

It must, however, be pointed out that there are certain limitations to the use of the alloy as a die-casting material. It is not a free-flowing alloy and should not be employed for castings of widely varying thicknesses, or for castings having a section of thickness less than about $\frac{1}{8}$ in. The feeding of a thick section through a thin one must be avoided and adequate feeds to all thick sections are imperative.

This need for heavy feed is further accentuated by the shrinkage which occurs on solidification. This feature, unless adequate feed be provided, will generally result in shrinkage cavities and draws. A certain degree of hot-shortness possessed by the alloy may also lead to complications, unless adequate radii be provided at all corners so that the metal may flow as freely as possible and that extraction from the die may be facilitated.

Die Design and Foundry Practice

These limitations, however, may be overcome in the majority of designs, provided that the correct foundry technique, along the lines indicated, be employed. The advantages which die-castings in the material possess for commercial-vehicle construction, especially on the score of lightness and ease and economy of mass production, well justify the necessary attention to die design and foundry practice.

Preventing Cooling Water Corrosion

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corrosion for oil engines or compressors; it is likely to form a hard scale which will lead to fractured cylinder heads and similar troubles, particularly with certain classes of water.

A particularly dangerous form of corrosion is that in which the metal becomes converted to a black substance which appears and feels like graphite. It stains the fingers as does graphite, and this form of attack has therefore become known as "graphitic wasting." The corrosion takes place from the water side, and if the metal is broken the extent of the attack is clearly shown in the distinct line of demarcation between the corroded (black) and uncorroded metal. The black portion may be readily cut with a penknife or other small implement, being quite soft.

This is the dangerous feature of this type of corrosion. Outwardly, the metal appears unchanged, but the corrosion may proceed to such an extent that only a thin shell of sound metal remains, which obviously will be in no condition to withstand working stresses. Analysis of the black corroded part of the metal invariably shows it to be black oxide of iron, and its formation is always due to the presence of dissolved gases in the water. This particularly insidious form of corrosion is therefore a final argument for the effective treatment of cooling water to avoid dangers from corrosion by either dissolved gases or free acidity.

Foundry Problems*

By BEN HIRD

The author is taking this opportunity to revive one of his Papers, published in the Proceedings of the Institute of British Foundrymen, 1925-6, Vol. 19, page 512, entitled "Gases Evolved from Heated Iron." A personal reason for so doing is the experimental work carried out by Mr. W. Y. Buchanan, published in THE FOUNDRY TRADE JOURNAL, December 21 and 28, 1939, and June 13, 1940, under the heading, "A Preliminary Study of Gases in Cast Iron." It is very gratifying that a metallurgist of Mr. Buchanan's ability and standing has at last taken up this subject, from a foundry standpoint. The author's Paper concluded with the following phrase: "Although these experiments are rather crude and incomplete, the author is confident that further investigation of the phenomenon along the lines indicated will be of considerable value to the foundry industry." It is to be hoped that Mr. Buchanan and others will carry on this work and aid the foundryman in eliminating or reducing one of his many troubles.

Three types of castings, chosen from many, in which the liberation of occluded gas, from one source or another, has caused trouble, will be dealt with, and a brief detailed description of the method of moulding may be of interest.

Three-Way Filter Pipe

Fig. 1 shows a rough sketch of a three-way filter pipe which at one time was used on oil tankers for filtering the crude oil. The first difficulty with this job was the lack of facilities for machining the seating marked A. This was overcome by making chills, machined to the correct angle, which were fixed to the core barrel. The core was made in a full core box, bolted up and rammed from the ends. Two sets of tackle consisted of a perforated barrel B and a smaller barrel C. A, B and C were held together by a stout eye bolt D. The branch E was carried by a cast-iron grid, bolted to the barrel. When the core was rammed up, it was suspended from the crane by a change hook in the eye of the bolt, the core box withdrawn, and the core removed to the stove, transferred to a light girder runway fixed to the stove roof, pushed into the stove and dried suspended. The chills were lightly coated with linseed oil and plumbago before drying. The filter was moulded and cast in a horizontal position. No trouble was experienced until twelve castings had been made. About 3 or 4 min. after the thirteenth mould had been cast, the metal quietly rose in the risers and more than ¼ cwt. overflowed.

When the casting was taken from the mould, a large area at the top of the filter was found to be a mere shell, which was indeed puzzling. An ordinary blow from the core seemed impossible; a hole in the side of the box part the size of the barrel formed an ample exit for all gas. When the next mould behaved similarly, it was time for a serious inquest, and finally suspicion centred on the chills. These were scrapped and replaced by new ones. There was no further trouble, as the chills were scrapped after being used for the fourth time. Occluded gas given off from the chills definitely caused the trouble.

A Composite Gudgeon Pin

Fig. 2 shows a section of a steel gudgeon pin, carrying a cast-iron head. The 4-in. dia. pins were machined up, and grooves and countersinks put in to hold the head. They were kept perfectly free from rust and slightly warmed just before casting. In the finished casting a centre was punched in the dome top, for holding in the lathe, and the punch frequently fell into cavities. Investigation proved that these came from gas given off by the pins.

Pug-mill Shaft

The engineer insisted on casting a 1¼-in. dia. steel bar in the pug-mill shaft shown in Fig. 3, although advised against it. The first casting was made in green sand and cast horizontally. Shortly after casting the metal quietly rose in the risers and overflowed, just as was the case with the filter. When the casting was removed from the mould, it looked sound, but closer examination revealed a cavity 2 ft. long in the top face. A second attempt was made with a dry-sand mould, this time cast on end, with a long down-runner as shown and without risers. The object was to seal any outlet from the mould as soon as possible after casting. To aid this, immediately the mould was cast, the runner box was filled with sand, covered with a plate and a heavy weight lowered on. At first the casting appeared to be sound, but the machining operation revealed a number of gas holes in the top end, as cast. Here again the trouble was caused by gas given off from the steel bar when heated up to a certain temperature. A third casting, made without the bar, was satisfactory in every way.

It was after these experiences that the experiments described in "Gases Evolved from Heated Iron"* were carried out. Moulders' sprigs, pipe nails, studs and chaplets were tested, all of which produced gas holes of varying amount, the sprigs being the worst offenders, and tinned studs the least. Further experiments to collect the gas given off were made, first from a length of steel tube, then from round cast-iron bars or chills, 2 in. dia. and 8 in. long. The first series had a 1-in. hole in the centre, leaving one end solid; in the second series, the hole was left out. The tests were all made with the chills suspended in round open sand moulds of varying diameters, the steel tube mould being 10 in. dia. and 13 in. long. All the cast-iron chills were tested in moulds 10 in. long, but 6 in., 8 in. and 10 in. dia. respectively. From the top of the tube and chills, connections were fixed and joined up to gas-collecting bottles. In all cases large quantities of gas were collected. The gas was tested in an Orsat Longue gas analysis apparatus and contained CO, CO_2, H_2 and O in various quantities.

Limiting Factors of Chills

Another simple experiment was made, which demonstrates one reason why inserts and chills can be successfully used in some cases, but prove failures in others. Two open sand moulds were made from a round plate pattern, 14 in. dia. and 1½ in. thick. The moulds were half-filled with molten iron, and when one had just set (approximately 870 deg. C.), a further layer of iron was poured on. The effect could be clearly seen, for gas bubbles were agitating the metal until it set. The second plate was allowed to cool down to 115 deg. C. before pouring on the second layer. When the plates were separated, the first one was honeycombed with gas holes and the second perfectly sound.

A further experiment was made to collect the gas from molten metal. The bottom portion of an old graphite crucible was thoroughly cleaned and a connecting tube fixed in the bottom, as shown in Fig. 4. A mould of 10 in. dia. was made and the gas-collecting bowl clamped in position. The mould was filled with metal until it just formed a seal round the edge of the collecting bowl, which was then connected to the bottle. Large quantities of gas were given off and the analysis corresponded with that given off from the chills. From these experiments and personal experience, the following conclusions have been made: (1) Gas is given off by cast iron in the molten state and during the solidification period, down to a definite temperature, not established. (2) In the reverse direction, when metal is heated up to a certain temperature, gas is given off. Therefore, the relative volume of chill or insert to the surrounding molten metal controls the time and amount of gas given off by the chills, etc., and its effect on the casting.

Fig. 5 is an attempt to show this diagrammatically. In A the metal will solidify before the chill reaches the critical temperature at which gas is given off; therefore, it cannot affect the casting. In B the chill will reach

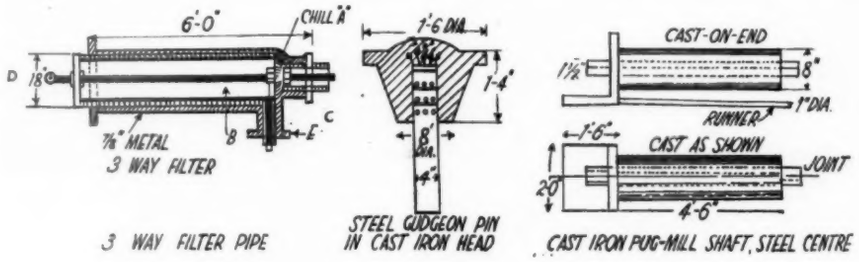

FIG. 1. FIG. 2. FIG. 3.

FIG. 4.—ARRANGEMENT FOR COLLECTING GAS.

* Paper read before the East Midlands Branch of the Institute of British Foundrymen, Mr. S. E. Dawson presiding.

* *Loc. cit.*

the critical temperature before the metal has set. The metal surrounding the chill and the walls of the mould will be like paste, whilst the rest will be liquid. Thus, gas liberated from the chill will be able to pass through the solidifying layer and expand to a larger cavity in the liquid metal. This is one reason why some chills and inserts give trouble and others do not.

Why some chills can be used a certain number of times before trouble from gas holes is experienced is another problem. An investigation of this, by sectioning and polishing and etching chills which had been used and which had started to give trouble, is shown in Fig. 6. A represents the depth to which the metal of the chill had been burnt. Burnt iron is not a good conductor of heat, so some of the rapid cooling effect of the chill has been lost; therefore, the molten metal surrounding it takes longer to solidify and the chill reaches that critical temperature when gas is given off, before the metal has solidified sufficiently to prevent the gas from penetrating and forming gas holes. In the experiments on the round cast-iron chills, it was noted that those with the hole in the centre gave better results than the solid ones. It has also been found in practice that it is an advantage to put vent holes in chills where possible. Moreover, where chills are almost surrounded by the molten metal, the chill should be used once only—this has now become general practice. It is cheaper to make a new chill than to risk a waster.

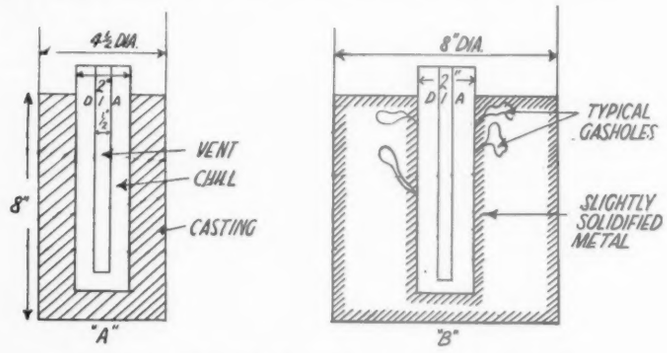

FIG. 5.—INFLUENCE OF CHILL SIZE ON GAS EVOLUTION.

DISCUSSION

MR. S. E. DAWSON (Branch-President) said that they had listened to a most interesting and practical lecture. Commenting on the author's experiments, he drew attention to the large amounts of dissolved gases which were present in molten steel and cast iron, and he suggested that much of the gas collected in the experiments was from this source. Such dissolved gases were liberated when the metal was cooling to a temperature between 700 and 800 deg. C., depending on the composition of the metal. They might amount to as much as four times the volume of the iron itself, when measured cold, and much greater than this at the temperature of liberation. Manganese had the effect of accelerating the evolution of gas from molten metal. He suggested that some of the gas was also due to chemical reaction between the graphite in the iron and the oxide of iron present in, or on, the densener or chill.

The Liquid Shrinkage Theory

MR. F. G. BUTTERS endorsed all the lecturer had said about the problem of blows from the sprigs. One thing that had occurred to him with regard to the heavy 10-in. by 10-in. blocks was that cavities could occur from liquid shrinkage, and not necessarily from gases given off from the chills.

MR. HIRD explained his reason for using such a large cylindrical block for a pattern. It was to ensure the collection of an adequate supply of gas. When starting the experiments he was very doubtful of collecting any gas at all, but, as shown on the slides later, test blocks of 6 in., 8 in. and 10 in. dia. were used. Mr. Hird then referred to an illustration showing broken sections of a test casting, where string had been inserted in the hole which connected the surface formed by the chill to the larger cavity adjacent. That was done to emphasise the connection to the chill.

The "Pushing Back" Phenomenon

MR. J. C. HALLAMORE said the members all appreciated the worth of Mr. Hird's original experiments. He would be interested to learn whether the two blocks were cast at approximately the same temperature, as that required to be taken into consideration. If an actual casting had to be produced to those dimensions, the big block would not be cast at the same temperature as the thinner casting. Such matters, in practice, were bound to make a serious difference. Mr. Hallamore asked what the author meant when speaking of the blowholes being "pushed back." He himself thought that the blowholes had pushed out so far and then failed to get through the casting. That was why the blowholes were at the top.

MR. HIRD apologised for the expression "pushed back": what he had wished to convey was the characteristic return of metal from the mould into the runner and riser as though the metal was quietly pushed out. That was quite different from the violent eruption known as "blowing." Referring to the temperature of the metal, Mr. Hird said the test moulds were not all cast at the same temperature; some were purposely cast with dull iron (details were given in the Paper previously referred to). The 2-in. dia. chill cast in the 6-in. dia. mould with dull iron produced no gas holes, but when poured with hot iron, gas holes developed. In the 10-in. dia. mould, the 2-in. dia. chills produced gas holes when cast with dull and hot iron, so agreeing with the theory advanced.

Occluded Gases

MR. H. BUNTING wondered whether they were right in terming many things "problems." They might be difficulties, or difficult points. Perhaps it could be said there was a distinction without a difference. Some of the matters termed "problems" were simply points in their own job about which they had not sufficient knowledge.

In his opening remarks Mr. Hird had referred to occluded gases. In several of the slides shown, the holes, or cavities, were around the top side of the casting. One would assume that if there were occluded gases they would be all round the casting, and not only on the top side. One would naturally assume the holes were blowholes.

Speaking of a chill that had been shown to be corrugated, Mr. Bunting asked whether the author did not think that might be due to the expansion of one and probably some contraction of the other, and nothing to do with gases at all. As the chill was heated it would expand and would try to force itself into the metal, whilst the metal would be starting to give a certain amount of contraction. The peculiar feature of the chill was that the corrugated part was more in the centre. Where they had the greater heat of the chill, there would be found that sinking phenomenon.

Material for Chills

In connection with chills and the gases given off, one point not mentioned by the lecturer was that if one chill was cast with a hard close iron, and another with an open iron, with the latter type more trouble would be experienced, and that could link up with the question of increase in size of the chill. If a hard iron were used for a chill, a much longer life was obtained.

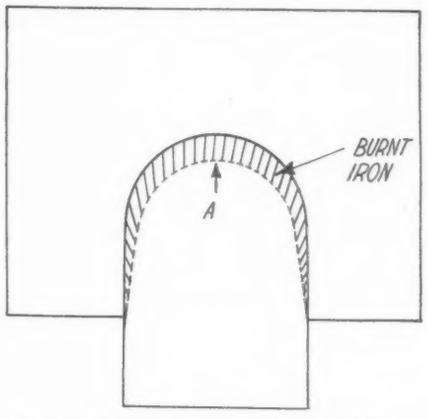

FIG. 6.—EFFECT OF REPEATED USE OF CHILLS.

He believed there would be a tendency for wet sprigs to show rust down the edges, and he had found that where a sprig had to go into the metal, it would cause blows unless it was clean.

Chill Distortion

MR. HIRD explained the distortion of the chills as being caused by the pressure of gas given off from the chill. This gas was unable to escape into the casting because of the quick solidification of a well of metal round the chill. This would create considerable pressure on the chill, which would be in an almost molten state due to the mass of metal surrounding it. Referring to the position of the gas holes in the test castings, many started from the centre but expanded in an upward direction. He exhibited some examples of test-pieces showing gas holes from sprigs. The gas holes surrounded the sprigs from the bottom to the top of the sprig where it was in contact with the metal. With regard to rust Mr. Hird had taken care to see that all the sprigs used were free from rust.

Gas Collection

MR. HOLLAND, referring to the test-tube method used by Mr. Hird for taking off the gas, said that much of the content of the bottle was probably hot air. He asked if a test had been made to see what sort of gas was in the bottle, as even a small quantity of air would expand and soon fill a 500-ml. bottle.

Discussing chills yielding a short life, he asked if it were possible, after a period when the chills had been heated up once or twice, that an absorption of carbon gas from the molten iron took place, in a similar manner to

(*Continued on next page.*)

Dendritic Structure

ITS INFLUENCE ON HETEROGENEITY

The first meeting of the Sheffield Metallurgical Association for the present session was held at the Metallurgical Club, Sheffield, recently, when Dr. C. H. Desch, F.R.S., formerly Professor of Metallurgy at Sheffield University and now Scientific Adviser of the Iron and Steel Research Council, gave an address on "Dendritic Structure."

Introducing his subject, DR. DESCH, whose lecture was illustrated with lantern slides and diagrams, said the first committee that was established in connection with the Iron and Steel Institute was the Heterogeneity of Ingots Committee, and thus heterogeneity had been studied ever since organised research work was undertaken by the steel industry. He proposed then to speak of one form of it. There were actually four degrees of heterogeneity that might be met with in a mass of metal. First of all there was the coarse separation into regions of different composition, which they called major segregation, certain parts of the ingot showing enrichment in certain elements. On a smaller scale, they had a similar enrichment in between the branches of the dendrites, which they called minor segregation. These were the two forms which were specially studied by the Ingots Committee.

The third form was one within the dendrites themselves. A dendrite which consisted of a single phase—excluding all inter-dendritic material—might yet have a composition gradient within it, so that the composition of the interior was different from that of the exterior; the core and the periphery differed from one another, but at the same time there was a gradual change of composition within the area, and no abrupt boundary. There was a fourth kind of heterogeneity, on a very minute scale indeed. One might, in an otherwise perfectly homogeneous solid solution, have small regions which were more ordered than others, or one might have ordered regions which were out of phase with one another; but this kind, although very important for certain physical purposes, might be neglected for their present purpose, so it was only the third degree of heterogeneity that he was speaking of—the existence of a composition gradient within individual dendrites.

Producing a diagram, the speaker said that when a solid solution solidified, they knew that if freezing began at a certain point on the temperature-composition diagram, the solid which separated under conditions of equilibrium had a given composition. When solidification had gone further, the solid should be in equilibrium with a new liquid composition. But that could not take place unless the solid phase changed its composition by diffusion, and a continuous process of diffusion was necessary for equilibrium. Under most conditions of cooling, they did not get that perfect diffusion. Diffusion in the solid state was a slow process compared with freezing, and therefore there was a lag between the freezing process and the adjustment of the solid to keep itself in equilibrium with the liquid. The result was that the solid phase, instead of being homogeneous, had changes in composition, the first portions, which represented the cores of the dendrites, having a position more to the left and the later portions more to the right.

That, of course, in a general way, was quite obvious and very simple, but the quantitative treatment of such a case was not at all easy. There had been few attempts to work it out quantitatively, the best of them being that by Gulliver a number of years ago, read to the Institute of Metals, on "Departure from Equilibrium in Rapidly Cooled Solids." Gulliver pointed out that one might represent imperfect diffusion by a rather simple analogy, by supposing that, as soon as a small quantity of crystals had separated from the liquid, it was taken away, then the remaining liquid was allowed to freeze and after an interval another fraction was taken away, and so on. In that way they got a succession of steps, and they could increase the number of steps by diminishing the intervals between them, and that gave them a result equivalent to imperfect diffusion so far as regarded the composition of the liquid that was left afterwards. Gulliver worked this out in a good deal of detail, and, taking a simple case, the lead-tin alloys, and dealing with a eutectiferous system, removing these crystals from time to time, the effect was that the quantity of eutectic found in the alloy was greater than that corresponding with equilibrium.

They could represent more rapid cooling by increasing the number of steps. There had not been worked out quantitative relations between the rate of cooling and the number of steps taken, but they got an analogy in that way, and they could work out the limiting case of an infinite number of steps, representing in that case such rapid cooling that there was no diffusion at all.

Gulliver worked out formulæ for finding the quantity of eutectic that would be left in an alloy, say, of lead and tin when the conditions of cooling were rapid. It could be applied to solid solution as well as to eutectiferous systems, only in the solid solution there was merely a difference between the outside and the inside. In that way Gulliver worked out the form that the solidus curve would take if determined under such conditions that diffusion was imperfect.

Construction of Equilibrium Diagrams

In determining equilibrium diagrams, if one had not allowed time for equilibrium to be obtained by diffusion, the tendency was to make the gap between the solidus and the liquidus larger than it should be—in a eutectiferous system to extend the eutectic line further to the left than it should be, and in the case of a solid solution to increase the range between the solidus and the liquidus. On the other hand, when the solidus was determined, as it so frequently was, by heating curves, the effect of lack of equilibrium was to give a bowed form to the solidus. That form was often found in published diagrams. In most of the published diagrams of the iron-carbon determination the curve representing the solidus, or the austenite region, was usually drawn of that shape.

In steels the solid solution, the austenite crystals, would show some such composition gradient within the dendrites, and that gave rise to the very well-known structure which one saw in nearly all steels when etched in a suitable way, unless they had had a long annealing. The chief composition gradient was in regard to phosphorus. High concentrations of phosphorus had the effect of expelling carbon, and so they found the carbon also differently distributed. They knew that this structure was of very considerable importance for practical purposes, because this coarse dendritic structure did persist through forging and had to be taken into account in determining the way in which, for instance, a crankshaft had to be forged.

(To be continued.)

Foundry Problems

(Continued from facing page.)

steel absorbing carbon in the cupola. The result might be that the chill became supersaturated, finally giving out its gas in a later cast.

MR. HIRD replied that, in the gas test, at least half a minute was allowed after the mould was poured before connecting the rubber tube, and gas continued to collect for from 20 to 60 mins. after casting. Records of this and the analysis of the gas were detailed in his previous Paper. He did not think that absorption of gas by the chill would happen, owing to the liberation of gas when the chill was heated. Rather was the burnt iron theory advanced the more probable.

Temperature Control and Blows

MR. GOODWIN said it was generally recognised that chills, especially internal ones, could only be used a certain number of times. He was inclined to think that many of the gas troubles Mr. Hird had referred to were due more to casting temperatures than anything else. The lecturer had stated that the one test-piece with dull iron gave the best results, but the speaker could not agree in practice with casting up dull iron, insisting that really hot metal would drive out the gases.

It would have been interesting if the author tried his experiment on the 10-in. dia. box at varying temperatures, and he asked if they would be poured hot or cold. The speaker's opinion was that this would eliminate the blows.

MR. HIRD agreed that when pouring moulds hot iron was essential to produce sound clean castings, but his experiments had had the object of determining the effect of temperature on the liberation of gases in chills and inserts. The effect of dull iron on the smaller diameter moulds round the same diameter chills was equivalent to that described in the diagram.

Vote of Thanks

MR. H. J. BECK, proposing a vote of thanks to Mr. Hird, expressed his interest in what Mr. Hird had called "blowholes," but which he preferred to call liquid shrinkage. During the week he had had a production job of which there had been quite a few made previously, but to his surprise, when this casting was sent into the inspection department, a small hole was found at the side of the flange. It was not large enough for an ordinary household pin to be inserted. After the casting was broken up, just under the small hole a larger cavity was found. All that the job needed, he said, was a small densener to be put at the side of it.

MR. GALE seconded the vote of thanks.

MR. HIRD thanked the members for their appreciation and lively discussion, which was very gratifying to a lecturer. Referring to the iob mentioned by Mr. Beck, he thought the gas hole in that case had come from the sharp corner of sand. The skin of metal had not set sufficiently to prevent the gas pushing through and expanding in the more liquid metal behind.

Fire-Resisting Asbestos Paint

John Line & Sons, Limited, of 213-216, Tottenham Court Road, London, W.1, have developed a fire-resisting asbestos paint primarily for domestic use as a preventive against the action of incendiary bombs. It carries the trade name "Home Guard," and appears to be potentially useful for applying to woodwork in and around foundries. Being of a smooth colloidal character, it is easy to apply either by brush or by power spray.

The Metallurgical Observer

ADDRESS IN SHEFFIELD BY MR. N. H. BACON

(*Continued from page* 339.)

With the modifications in ladle equipment, controlling the rise of metal in the mould, to the point where the metal tended to cream or ice on the rising surface, became practicable. In spite of this practice occasional casts are tapped at temperatures so high that cracking of the ingot occurs. When this happens the mill observer has to use his judgment when the ingots are rolled. If the cracking is slight and he considers the defects resulting will be satisfactorily dealt with, by chipping or flame dressing the billets, he allows rolling to proceed. If the cracks are more severe than this the ingot is sent back after the first few passes and stood up in a water-cooled steel box having vertical slots down each of its four sides. The cracks are then dressed out by means of an oxy-acetylene torch, inserted through the slots. In this way cracks can be dressed out in about one-tenth of the time it would take if the ingots were allowed to go cold, and of course the necessity for heating up again from the cold is eliminated. The mill people also made considerable improvements in the heating practice and took the necessary steps to eliminate over filling of the passes; roller twist guides were introduced to do away with the guide scratching, which was a continual source of trouble, particularly on the smaller billet sizes, 2½ in. sq. and under.

On certain qualities of steel it was found advantageous to do the rolling in two steps, and bloom-heating furnaces were provided to permit of this being done. This secondary scaling of the surface eliminates many small surface defects which might otherwise give trouble. It is now established that the close co-operation of melting shop and mill, helped by the detailed information which the metallurgical observers were able to provide, resulted in a steady improvement from year to year in the quality of the product, as indicated. A list of defects from 1931 is as follows (per cent.):—1931, 8.0; 1932, 6.81; 1933, 5.29; 1934, 4.76; 1935, 4.81; 1936, 4.35; 1937, 3.76; 1938, 3.68; 1939, 3.38; 1940, 3.21.

Statistical Method of Examining Steelworks Data

In any process where a large number of factors play a part, examination by statistical methods is often by far the quickest way of determining if this, or that, particular item has any influence on the ultimate results. As an example, it was suggested a few years ago that putting ingot moulds into service soon after they were cast had an adverse effect on the life; that resting them for a period before putting into service might prove beneficial. The results obtained on 682 moulds of a standard size, which had had their service in the Templeborough melting shop, were examined (Table I).

TABLE I.—*Statistical Analyses of Lives of Moulds.*

Time lapse between casting the mould and putting into service.	No. of moulds.	Average life. (Casts).
Within 1 week ..	54	86
1 to 2 weeks ..	257	84
2 „ 3 „ ..	108	85
3 „ 4 „ ..	76	85
4 „ 8 „ ..	134	85
8 „ 12 „ ..	37	85
12 „ 16 „ ..	16	85

This is far more convincing than putting, perhaps, six moulds into service immediately after casting and comparing them with six moulds which had been allowed three months' rest. One or the other group might show the longer life, due to factors quite apart from the one under consideration. It becomes necessary to take a number large enough to ensure the equalisation of the many other interfering factors.

The following is a good example: Some years ago considerable trouble arose owing to sand inclusions in tyre steel. An examination was made of 199 casts of steel, all made in the same size of moulds, 14-in. by 12-in. sides. These casts were arranged, in the first place, according to the incidence of sand defects, and the averages were taken out for a large number of items, which, it was thought, might have a bearing on the results. The two items which showed any marked variation were the carbon and silicon content of the steel (Table II).

TABLE II.—*Effect of Composition on Sand Defects.*

Sand defects, per cent.	No. of casts.	Average. C	Average. Si	Average. Defects, per cent.
Less than 1.0 ..	23	0.55	0.274	0.55
1 to 2.9 ..	56	0.57	0.271	1.96
3 „ 4.9 ..	62	0.55	0.274	3.84
5 „ 7.9 ..	34	0.60	0.277	6.06
8 „ 9.9 ..	11	0.66	0.286	9.16
Over 9.9 ..	13	0.66	0.288	12.99

Grouping the casts according to their carbon content is shown in Table III.

TABLE III.—*Grouping according to Carbon Content.*

Carbon, per cent.	No. of casts.	C	Si	Defects, per cent.
0.40 to 0.49 ..	60	0.45	0.282	3.2
0.50 „ 0.59 ..	40	0.55	0.268	3.43
0.60 „ 0.69 ..	56	0.62	0.273	4.82
Over 0.69 ..	43	0.72	0.283	5.49

Grouping the casts according to their silicon content gave the results shown in Table IV.

TABLE IV.—*Grouping according to Silicon Content.*

Silicon, per cent.	No. of casts.	Average. C	Average. Si	Average. Defects, per cent.
0.23 to 0.259 ..	50	0.57	0.246	3.12
0.26 „ 0.279 ..	56	0.57	0.268	3.99
0.28 „ 0.299 ..	62	0.56	0.286	5.1
0.30 and over ..	31	0.63	0.311	5.0

The casts were next split into two groups, 0.27 per cent. Si and less, and over 0.27 per cent. silicon, and then sub-divided according to their carbon content (Table V).

TABLE V.—*Classified according to Silicon Content.*

Casts 0.27 per cent. Si and under. Carbon, per cent.	No. of casts.	Defects, per cent.	Casts over 0.27 per cent. Si. No. of casts.	Defects, per cent.
0.40 to 0.49 ..	20	2.7	40	3.4
0.50 „ 0.59 ..	24	2.8	17	4.4
0.60 „ 0.69 ..	23	3.4	33	5.6
0.7 and over ..	15	4.4	28	6.0

The influence of carbon will be noted on casts having a similar silicon, and the influence of silicon on casts having similar carbon. The carbon content required is governed by the tensile strength called for, but the silicon content is within the control of the steelmaker.

The sand defects have been reduced from an average of 4.2 to 0.3 per cent. The biggest single factor, perhaps, in bringing about this reduction was the institution of systematic examination and dressing of the cut blocks before charging into the tyre-mill furnaces. The chippers are paid a bonus according to the results achieved. This bonus is in two parts. One part is based on sand defects found in the tyres; it reaches a maximum with no sand defects, and is nil if the defects are 3 per cent. or more. With this inducement alone, the chippers would be inclined to reject any doubtful block, and so the other part of the bonus is based on the chipping results. If no blocks are scrapped, the bonus reaches the maximum; if 3 per cent. or more of blocks are scrapped, there is no bonus paid. It is to the chippers' interest, therefore, to make every block good, and they draw attention, in no uncertain fashion, to any cast below par. This gives the steelmaker a chance to see any defective steel at a stage when the class of defect is beyond dispute, a much more satisfactory method than viewing the defective tyres, when the cause of the defect has been largely obscured during the process of heating and rolling.

Corner Segregation

Another example which may be cited, of the value of systematic observation, and recording, refers to corner segregation in alloy steel. It had been the practice in the case of a certain class of alloy steel to turn the octagon ingot in the lathe until all trace of corner segregation was removed; this was checked by sulphur printing as turning proceeded.

Systematic recording revealed several interesting features:—The fault was confined to one, two or three adjacent corners. These corners coincided with the side of the ingot adjacent to its neighbour, the moulds being set in pairs. Some improvement resulted from wider spacing of the moulds. A reduction in teeming speed resulted in much less corner segregation, but trouble arose due to sand inclusions, owing to sluggish metal resulting from too slow teeming. Correlation of the mould with the ingots made in it yielded an interesting result. In the following tabulation the mould number is shown and the absence, or otherwise, of corner segregation in the ingots produced from each mould.

The size of the mould is 26 in. octagon:—O = freedom from corner segregation; X = presence of corner segregation. Mould No. 10 (OOXX), No. 13 (OXOXX), No. 15 (OXXOXO), No. 18 (XOXOOO), No. 21 (OXXOO), No. 22 (OXXO), No. 23 (OXXXO), No. 26 (XXXOO), No. 29 (XXXXXXX), No. 31 (OXXXO), No. 39 (OXXOO).

It will be noted that mould No. 29 failed to produce one ingot out of seven free from corner segregation. This mould was examined carefully, but did not show anything to account for the poor result obtained.

The suggestion was made that deepening the corners of the moulds, by machining, might cure the trouble, so, as an experiment, mould No. 29 was machined. The result was startling, for whilst one continued to get 50 per cent. or more corner-segregated ingot from the standard moulds, mould No. 29 commenced producing sound ingots every time it was used. It became clear that the contour of the octagon mould was of overriding importance in connection with the problem. Now that the corners had been deepened, it was found that the radius of the inverts was the same as the radius of the inner dimension of the mould, *i.e.*, 13 in. This led to an examination of the whole series of octagon moulds from 24 to 63 in., and it was found that the radius of the invert was in all cases less than the radius of the inner dimensions of the mould.

All the moulds are now made with this deeper invert, *i.e.*:—24-in. octagon, radius of inverts, 12 in.; 28-in. octagon, radius of inverts,

For High Quality Castings

The increasing demand for high-strength close-grained iron castings calls for improved metal. In comparison with the accepted standards of the past, the modern high quality casting requires lower total carbon and phosphorus, with a closer range in silicon. The Ironfounder can now meet this demand at a reasonable cost by the use of Stanton-Dale Refined Pig Iron.

Stanton-Dale is a pig iron of low total carbon, the graphitic carbon being uniformly distributed and of fine curly-flake formation. The close structure ensures remarkably high strength with good machineability, and Tensiles of 16 to 20 tons can readily be obtained when a proportion of Stanton-Dale Iron is introduced.

The use of this iron avoids the irregularities in structure which are sometimes observed when steel scrap has formed part of the charge.

The correct grade of Stanton-Dale Iron to use depends on the type and class of castings to be made. The Stanton Technical Service is available to advise on suitable mixtures.

Total Carbon from 2.6 per cent. upwards. *Analysis to individual specification as required.*

STANTON-DALE
REFINED PIG IRON

The Stanton Ironworks Company Limited, Near Nottingham

The Largest Producers of Foundry Pig Iron (for Sale) in Great Britain

14 in.; 54-in. octagon, radius of inverts, 27 in.; and so on.

For the past two years, with the redesigned mould, there has been no further instance of corner segregation. Instead of annealing and turning, the ingots have gone hot to the press for forging, which procedure has taken a considerable load off the annealing furnaces and lathes.

Life of Ingot Moulds

Another example of the value of systematic observation and recording, in conjunction with periodical statistical examination of data, is that of ingot moulds. The factors affecting mould life are very numerous, for, apart from the quality of the mould metal, there is the influence of design; chemical composition; frequency of use; method and speed of teeming; temperature and chemical analysis of the steel cast; time lapse between casting and stripping the ingot; method of stripping, and so on. The study of the subject made during the past ten years has led to modification in design; method of grouping; chemical analysis; and improved supervision in the stripping, setting and rotation of usage. The silicon content has been found to have an important bearing on the life, and this has gradually been reduced from the 1.8/2.2 per cent., at which it had stood for many years, to 1.0 per cent. Si; 0.8 per cent. has been found to be the lower limit advisable; below this the life falls off.

It has recently been found that phosphorus also has an important influence on the mould life, but its effects had, up to recently, been obscured by the large variation in the silicon content. The effect of phosphorus content higher than 0.1 per cent. is now being investigated.

The general result on the mould consumption of this systematic and sustained study is shown in the following tabulation:—Semi-closed top mould consumption (lbs. per ton): 1932, 26.05; 1933, 25.52; 1934, 24.97; 1935, 20.42; 1936, 18.90; 1937, 16.05; 1938, 15.03; 1939, 14,96; 1940, 15.84.

Efforts made to improve mould life have, up to recently, been largely confined to improvements in design; chemical analysis; and improving the casting pit conditions generally, and although a steady decline in mould consumption has been the result, there still remains the task of reducing the gap which exists between the longest and shortest life mould. One may take 20 moulds of the one pattern, of the same chemical analysis, and use them together throughout their lives in the one set, so that each receives the same quality of steel, and as far as humanly possible the same treatment throughout its life, as all its brother moulds in the same group. When one has done all this the average life of the group may be satisfactory, 140 lives or 14.3 lbs. per ton, but viewed individually the lives will be found to vary from 115 to 165, and this variation in life must be attributed to variations in the quality of the mould metal, variations other than that of chemical analysis.

What is badly needed is some test, which can be made at the time the mould is cast, which will serve to indicate the suitability of the metal for mould manufacture.

DISCUSSION

PROF. J. H. ANDREW said there had always been a very loud call for practical Papers dealing with works operations, and he thought that Mr. Bacon had gone a long way to satisfy them in that direction.

MR. R. PERCIVAL SMITH (works director, Steel, Peech & Tozer) said it had been his privilege to see the work of the metallurgical department grow and develop, but though he had heard about all the things at first hand that the speaker had mentioned in his interesting lecture, they seemed as fresh as if described for the first time.

MR. T. F. RUSSELL said he noticed how the curve showed that the mould life improved when the phosphorus was increased to 0.1 per cent. The improvement seemed to be so rapid that he wondered why they stopped at 0.1 per cent. Was the life a maximum with that quantity, or had higher percentages been tried?

MR. BACON said they had tried larger percentages, but there was such a long lapse of time between manufacturing a mould and getting the results that they could not yet say what the effect was. With regard to silicon, they had found the life increase as Si decreased to as low as 0.8 per cent., but when they went down to 0.6 per cent., the life shortened. They were now investigating the effect of 0.2 or 0.3 per cent. phosphorus.

MR. H. BULL said that many of Mr. Bacon's observations about testing steel interested him, particularly the "jump" (upending) test, as that was perhaps one of the most effective tests for finding seams. Maybe a better one, if it were possible to practise it more, was to do an electrical upset, which seemed to be the method that detected little seams and made them look like craters. As to mould analysis, Mr. Bacon had perhaps an advantage over a firm which was always using acid furnaces, because, having got the phosphorus pretty high, he could remove it in a basic furnace. At his (the speaker's) firm, where acid steel is made, they had thought themselves rather unfortunate on two occasions, both during wartime. During the last war they had to use high-phosphorus iron for moulds, but they found that the mould life was increased in some cases by using high-phosphorus iron; it appeared to be an effect of phosphorus. Recently they had had some pig-iron, rather high in phosphorus, and again the mould life seemed to be no worse because of the higher phosphorus. The unfortunate thing was that such moulds, having finished their life as such, could not be remelted in an acid furnace because of the high phosphorus, whereas moulds made of low sulphur and phosphorus hematite iron could be so used. They felt, however, that many things affected the mould life, which Mr. Bacon probably knew all about, but had not touched upon. Concluding, the speaker said that he presumed that Mr. Bacon, when speaking about tyre steels, was referring to acid steels. He was most amazed to hear that carbon and silicon could make so much difference to the number of rejections, due to sand and other non-metallics, and he wondered whether Mr. Bacon really did mean that it was carbon and silicon that made the difference, or did the carbon and silicon, particularly the silicon, indicate some steelmaking feature which was reflected in the quantity of silicon that happened to be in the charge and had actually nothing to do with the real cause of the troubles?

As to statistics, the fact that Mr. Bacon suggested they might do a little more in their preparation and examination, appalled him. He was tired of seeing forms which wanted filling in. If Mr. Bacon could find some sort of automaton that could fill them in, the metallurgical world would feel that he was a real benefactor.

MR. BACON, in reply to Mr. Bull's last point, said they made use of comptometers in making the statistical analyses. As to mould analysis, he agreed that it would play no important part if the service was severe, but when the moulds were given a fair chance, the analysis had a definite bearing on the life. As regards silicon, he quite agreed that it was probably an indicator of some other condition.

Ingot-Mould Consumption in Germany

MR. PERCIVAL SMITH said it had often been said that in this country they had not been able to do as well with their moulds as had the Germans. This was mentioned at a meeting in Sheffield a few days ago. It was, however, a misconception, based on the way in which the German mould figures were presented. What was no doubt in the mind of the speaker at the meeting referred to was a figure for mould life in Germany of 200 to 300 casts. One had to know the circumstances to appreciate what that figure meant. Mr. Bacon and the speaker, on a visit to Germany in 1936, paid close attention to mould consumption in German works, and found that the Germans were using moulds, originally 5 in. thick, until they had to force the ingots out of the moulds so violently that, when a mould was scrapped, the wall thickness was reduced to 3 in. Expressed in lbs. of metal per ton, they would find that the relationship was quite a different one. In a recent review of mould performance in Germany, in which were compared 40 works, the average mould consumption was stated to be 23 lbs. per ton, whereas for moulds used in casting ordinary commercial qualities the corresponding figure quoted by Mr. Bacon was 15 lbs.

DR. R. J. SARJANT, proposing a vote of thanks to Mr. Bacon, said both that gentleman and his colleagues were to be congratulated on the results of their work. In principle, he thought they could agree that the study of works practice by means of the scientific methods which Mr. Bacon had applied was just the thing that was wanted in the steel industry of this country to-day. Mr. Bacon had shown them that in a very short time many interesting facts had been discovered. He did not think there were any truer scientific workers than those who were working in a pioneer field of the kind described in the lecture. Mr. Bacon had asked whether other works had applied the mathematical method. He (Dr. Sarjant) was a great believer in it. It was amazing how definite the results became if one applied the proper statistical method. The work and the success of the actuary were indisputably based upon the application of quite abstruse mathematics, and the statistical method, when one considered all the implications of the laws of probability, could be carried to a high standard of mathematical research. There was such a thing as the frequency of occurrence curves which, when applied to an unintelligible set of results, looked discouraging on a chart, but, when analysed by the proper methods, provided the instrument of discovery. They could get from them an inkling of what the trend of the results was; then, if they wanted to prove the truth of their tentative conclusion, they could devise some *ad hoc* experiments and provide a final solution of the problem.

MR. MALCOLM BROWN, in seconding, said to him the charm of the lecture had been the practical side of it. Mr. Bacon had come along with a lot of experience and had given them the results; he had not just propounded theories as to what might be done. The point he was glad to hear stressed was that the keenest observers in any shop could as a general rule be taken to be the men in the shop.

The vote was carried with acclamation, and was briefly acknowledged by Mr. Bacon.

British Standard Specifications

Among new and revised specifications issued by the British Standards Institution are the following, which may be obtained from their offices at 28, Victoria Street, London, S.W.1 (price 2s. 3d., post free, each):—

Oxy-Acetylene Welding in Mild Steel.—The revision of BS/693, Oxy-Acetylene Welding in Mild Steel, was mainly undertaken in order to bring the requirements specified in this Standard into line with the recently issued code of the London County Council in connection with the conditions for the granting of permission to use oxy-acetylene welding construction in London. At the same time the question of tests on welds has been reconsidered and provision is now made for more simple tests to be carried out which are considered to be sufficient to ensure sound welding. The requirements of this Standard do not apply to structures comprising tubular members but a draft to cover these is now in course of preparation by the British Standards Institution, and it is hoped that it will be issued shortly.

Steel Tubes and Tubulars.—In 1938 the British Standards Institution published the BS/789 for steel tubes and tubulars of gas, water and steam qualities. To meet the urgent need for the utmost economy in the consumption of steel a War Emergency British Standard superseding that issued in 1938 has now been prepared at the request of the Ministry of Supply and with the full co-operation of the manufacturers. It provides for the replacement of the three qualities of tube in the 1938 issue, namely, gas, water, and steam qualities, by two qualities designated respectively, "light weight," and "heavy weight."

Optical Smoothness Meter

An optical smoothness meter for determining the surface finish of metals, described by J. GUILD in the "Journal of Scientific Instruments," measures the ratio of specularly-reflected light to the light totally reflected in all directions. The method is very sensitive for comparing the smoothness of flat surfaces.

FRY'S SOLDER & FLUX REFERENCE TABLES

For many years Fry's Metal Foundries have maintained a research staff investigating not only the purely scientific problems connected with the production of better solder and fluxes, but also the practical problems confronting the ordinary and the specialised solder user. We shall be pleased to co-operate in the solution of solder users' difficulties and to give metallurgical advice. Copies of technical publications on solders and fluxes supplied free on request.

HIGH TEMPERATURE SOLDER

for hot water appliances, armatures, and any soldered joint to resist temperatures of over 100° C. (212° F.).

Number	Melting Range	Brinell Hardness at 15° C.	Brinell Hardness at 100° C.	Brinell Hardness at 180° C.
H.T.3	235/240° C.	10.3	5.45	3.0
L.S.1	305/312° C.	7.1	5.35	3.0
L.S.2	305° C.	7.1	4.95	3.0

FUSIBLE SOLDER

Grade	Melting Temperature C	Melting Temperature F	Grade	Melting Temperature C	Melting Temperature F
Fry's No. 2 Alloy	70°	158°	Fry's Tube Bending Alloy	71°	160°
Fry's No. 9 Alloy	93°	203°			
Fry's No. 15 Alloy	138°	281°	Fry's Alloy for Die and Punch Mounting	120°	248°
Fry's No. 17 Alloy	124°	256°			

DIPPING SOLDERS

Grade	Melting Range	Using Temperature	Weight : lb./cu. in.	Weight : lb./cu. ft.
T.R.	183/210° C.	280/300° C.	0.32	552.96
No. 1	183/230° C.	310/330° C.	0.338	584.0
2	183/255° C.	330/350° C.	0.325	608.256
3	183/290° C.	340/400° C.	0.372	642.816

TINMAN'S SOLDERS

Grade B.S.S.	Melting Temperature	Tensile Strength : tons/sq. in.	Elongation %	Brinell Hardness
A	185° C.	4.9	20	13.9
B	205° C.	4.4	67	12
C	230° C.	4.1	63	11.3
D	255° C.	3.8	53	8.7
F	210° C.	3.8	69	12
K	185° C.	4.0	52	13.9

DIPPING FLUXES

ACTIVE	"FRYSOL" Soldering Fluid "FRYSOL" 3	An active flux suitable for dipping of steel, copper, brass and all general work. Approved for A.I.D., I.N.O. and W.O. work. Recently developed active flux similar to "FRYSOL" but having especial advantages for small dipping work. It has a high wetting power and eliminates spattering when the work is immersed in the molten solder.
SAFETY OR PROTECTIVE	FRY'S OLEIC ACID No. 9 "FRYOLENE" Liquid Flux No. 1	Safety flux approved by: Admiralty, K/767; War Office, CWD/712/A; Air Ministry, AIR/58/1. Suitable for copper, brass and other non-ferrous alloys; may also be used for iron and steel if these are thoroughly cleaned. The flux residue is non-conductive. Safety flux suitable for certain types of iron and steel, nickel and chromium alloys, in addition to non-ferrous alloys. Does not cause spattering. The residue, which is non-corrosive, can be removed with warm water. *N.B.*—"Frysol" 3 and "Fryolene" Liquid Flux are both inflammable and should not be used in large quantities adjacent to naked lights.
COVERING FLUXES	"FRYSOL" Salt	This readily melts when sprinkled on the surface of molten metal, thus preventing excessive oxidation and consequent loss in tin content.
CLEANING & REFINING FLUXES	FRY'S R.2. Flux FRY'S FLUX TABLETS	Contains in finely powdered form an active flux which coagulates the surface oxide and releases the entrapped metal. Have the same effect because they burn on the surface of the bath producing intense local heating. They are especially suitable where a safety flux is used for dipping. After the use of either of these fluxes, the dross, now very much reduced in quantity and consisting of finely powdered oxide, is skimmed off.

SOLDERING FLUXES

TYPE A: "PROTECTIVE FLUXES"			TYPE B: "ACTIVE FLUXES"	
"Alcho-re" (Soldering Fluid) / (Soldering Paste)	A.I.D. / W.O. CWD/275C / I.N.O. K./767	Non-Corrosive Safety Fluxes	"Frysol"—	
Oleic Acid No. 9			Tinning Salt / Soldering Fluid / Soldering Paste Flux	Fluxes for all General Soldering, Dipping, etc.
"Fryolene" Paste Flux—Rapid action, Non-corrosive Flux for Ferrous and Non-ferrous Metals				
Zinc Flux	Non-corrosive Flux for Zinc and Zinc Alloys, and Galvanised Iron		"Fryolux" Solder Cream / "Fryolux" Solder Paste	A mixture of high grade solder and flux combi ed.

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The Week's News in Brief

Trade Talk

WAGE INCREASES of 5 per cent. for all workers in the cutlery trade have been approved by the Cutlery Trade Board.

EMPLOYEES of the Cannon Iron Foundries, Limited, Deepfields, Bilston, have contributed more than £405 to local hospitals during the past year.

AN Abrasive Industries Export Group has been formed, with Mr. W. M. Rowland as chairman and Mr. J. A. Orchard, Universal Works, Stafford, as secretary.

MR. A. G. MARSHALL, 2, Howard Street, London, W.C.2, is secretary of the Heating Appliances and Accessories Export Group, which has just been established.

HILMOR, LIMITED, makers of tube-bending machinery, of Calshot Street, London, N.1, have established temporary offices at London Road, Knebworth, Herts.

COX & DANKS, LIMITED, iron and steel scrap merchants, have opened an office at Prudential Buildings, Mill Street, Bedford. Mr. L. Wallace is the manager.

IT WAS RECALLED at a meeting of the Glasgow University Engineering Society that this year makes the centenary of the founding of the first Chair of Engineering at the University.

ITALIAN PRODUCTION of pig-iron in January to June is reported at 551,000 tons, as against 429,000 tons in the parallel period of 1939. Steel output at 1,190,000 tons was 7 per cent. higher than in the corresponding period of 1939.

A FIRM of constructional engineers has been fined £3 for contravening the Undertakings (Restrictions on Engagement) Order, 1940, by engaging workers otherwise than by notifying a local office of the Ministry of Labour.

DURING THE FIRST seven months of 1940, the production of pig-iron in Brazil amounted to 104,000 metric tons, and it is officially estimated that output in the full year will reach 200,000 tons, compared with 160,000 tons in 1939.

NASMYTH WILSON & COMPANY, LIMITED, are being wound up voluntarily. Mr. Albert Holden, 8, The Sanctuary, London, S.W.1, is the liquidator. A declaration of solvency has been filed. All the debts of the company have been or will be fully discharged.

ALTHOUGH AN AGREEMENT has been made between Germany and Spain in regard to ore deliveries, Germany has for the moment little use for Spanish ore. As exports to Great Britain have diminished since August, several Spanish ore mines have been closed down, reports the Lisbon correspondent of the "Iron Age."

THE BLAST-FURNACEMEN of an area which has had numerous alerts since the beginning of June have now started working through air raid warnings. The decision follows several weeks of experiment and testing the efficacy of roof spotters, together with an additional warning received after the sirens indicating more imminent danger.

THE THIRD of the Air-Raid Precautions Training Bulletins issued by the Ministry of Home Security has now been published. These training bulletins are intended chiefly for the benefit of instructors, more particularly those in industrial and commercial establishments who have not the same opportunities for keeping in touch with the latest developments in air-raid precautions as the staffs of local authorities. They contain all the most recent information and guidance on the subject. Bulletin No. 3 consists mainly of important notes concerning anti-gas, high explosives and incendiary bombs. It is published by H.M. Stationery Office, York House, Kingsway, London, W.C.2, price 5d. post free.

DR. K. G. FENELON, Director of the Department of Industrial Administration, College of Technology, Manchester, and head of the department in Manchester University, read a Paper on problems of war-time labour management before the Royal Society of Arts in London recently. Dr. Fenelon said that long unbroken spells of work stretching over four or five hours had been found to be undesirable, and it was now a fairly common practice to introduce short "rest pauses" during the morning and afternoon shifts. Experience among firms which had introduced rest pauses showed that output was often increased from about 5 per cent. to 10 per cent. and sometimes by even as much as 15 per cent.

AT THE annual meeting of the Central Board of the Shipbuilding Employers' Federation, held in Carlisle recently, Mr. J. M. Ormston, shipbuilding manager of Vickers-Armstrongs, Limited, Barrow-in-Furness, was elected President for the coming year, in succession to Mr. Henry Main, managing director of the Caledon Shipbuilding & Engineering Company, Limited, Dundee. Mr. H. B. Robin Rowell, director of R. & W. Hawthorn Leslie & Company, Limited, Hebburn-on-Tyne, becomes the senior vice-president. Mr. Louis V. Dunlop, general manager of Harland & Wolff's Govan shipbuilding yard, and Mr. Wilfrid Ayre, chairman and managing director of the Burntisland Shipbuilding Company, Limited, were also appointed vice-presidents. Mr. G. R. Green, of Silley Cox & Company, Limited, of Falmouth, was elected chairman of the conference and works board, with Mr. A. L. Cochrane, director of Cochrane & Sons, Limited, Selby, as vice-chairman.

Personal

MR. MICHAEL DEWAR, chairman of British Timken, Limited, has been nominated a Sheriff for the county of Hertfordshire.

MR. LESLIE F. WRIGHT, a director of Gjers Mills & Company, Limited, Ayresome Ironworks, Middlesbrough, is to continue as President of the Cleveland Institution of Engineers for another year.

MR. F. SMITH, who has been with Barnes & Pye, Limited, ironfounders, of St. Miles Foundry, Norwich, for 55 years, has retired. He was presented with a Westminster chiming clock by the workpeople.

THE COUNCIL of the Institution of Mechanical Engineers have awarded the James Watt International Medal to Prof. Dr. Aurel Stodola. He is well known for his work on the development of a scientific basis for steam-turbine design.

MR. WALTER PARKER, who hitherto has demonstrated the products of Kingscliffe Super Refractories, Limited, and Durhills, Limited, has been appointed technical manager to the group of companies controlled by Hinckleys, Limited, of Sheffield, and demonstrator of the Randupson cement moulding process.

Obituary

MR. CHARLES VALON BENNETT, who died at Rochester last week, was a past-president of the Institution of Gas Engineers. He was 53 years of age.

THE DEATH has occurred at Paisley of Mr. Robert Blackwood McLeish, a retired ironfounder. Mr. McLeish was one of the founders in 1887 of McLeish & McTaggart, Victoria Foundry, Paisley, and before commencing business on his own account, he was with A. F. Craig & Company, ironfounders and engineers, Paisley.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

West Smethwick Metal Company, Limited, Alexander Works, Oldbury Road, Smethwick—Capital, £1,000. Directors: T. A. and V. E. Alexander, and T. Ball.

Hard Metal Tools, Limited—Capital, £91,600. Three of the first directors are to be appointed by A. C. Wickman, Limited, and two by Kleinwort, Sons & Company. Subscriber: A. H. Jarrard, Tudor Cottage, Blackdown Hill, Leamington.

Coventry Grinders, Limited, 114A, Earlsdon Avenue, Coventry—Capital, £10,000. To take over the business of grinders and gauge makers carried on by Roland Gibson and Chas. Castledine. Directors: P. Gibson, O. Castledine, J. A. Roberts, and A. H. Pattison.

Reports and Dividends

W. G. Allen & Sons (Tipton), Limited—Interim dividend of 2½ per cent.

J. H. Fenner & Company, Limited—Final dividend of 5 per cent., making 10 per cent.

Henry Berry & Company, Limited—Net profit for year to August 31, £9,157; brought in, £5,097; preference dividend, £2,070; ordinary dividend of 12½ per cent., £3,594; carried forward, £8,690.

Dorman Long & Company, Limited—Net profit for the year to September 30 last, after taxation, £956,179; brought in, £157,501; dividends of 15 per cent. on the preferred ordinary and 7 per cent. on the ordinary shares; to depreciation, £275,000; carried forward, £156,915.

Birmingham Small Arms Company, Limited—Profit for the year to July 31 last, £825,972; brought in, £280,154; debenture interest and fees, £70,876; reserve for income tax, £475,000; to general reserve, £119,410; dividend of 7½ per cent. on the ordinary stock; carried forward, after preference dividends, £301,065.

Frederick Braby & Company, Limited—Profit for the year ended September 30, £342,528; reserve for taxation, £228,000; brought in, £55,245; depreciation, £27,643; to employees' reserve account, £8,000; to suspense reserve, £15,000; dividend on the preference and employees' stock, £13,510; interim dividend of 6d. per £1 unit on the ordinary stock, £11,375; final dividend on the ordinary stock of 1s. 6d. per £1 unit, £34,125; additional dividend on the employees' stock of 7.2d. per £1 unit, £1,440; carried forward, £58,111.

Contract Open

Huddersfield, December 18—Cast-iron pipes from 2-in. to 12-in. internal dia., and various castings, for the year 1941, for the Waterworks Department. Mr. James P. Beveridge, waterworks manager, 24, Ramsden Street, Huddersfield.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

524,272 BREVETS AERO-MECANIQUES SOC. ANON. Electrolytic polishing of metals, particularly steel.

524,362 SHELL MARKETING COMPANY, LIMITED, and RIGBY, R. Case hardening of ferrous metals or ferrous alloys.

524,383 WROE, T. K. Heating of metal in feeder heads, risers, or moulds.

524,420 KRUPP AKT.-GES., F. Manufacture of permanent magnet alloys.

524,422 METALLGES. AKT.-GES. Rotary-drum furnaces.

524,476 KERR, R., and MACNAUGHTAN, D. J. Process for the treatment of tinplate, and tinplate articles, to prevent staining and discolouration.

524,479 PIEL, C. Metal moulds.

524,566 WITHERS, J. S. (Morrow, J. G.). Alloy steels particularly suitable for welding.

524,607 MACDONALD, J., and G. W. B. ELECTRIC FURNACES, LIMITED. Conveyors.

Forthcoming Events

DECEMBER 9.

Sheffield Society of Engineers and Metallurgists:—"Speed and Continuity of Operations in Glass Production," Paper by Prof. W. E. S. Turner, at Sheffield.

Institute of British Foundrymen

DECEMBER 7.

Lancashire Branch:—"The Foundry—Past, Present and Future." Paper by F. Dunleavy, at Manchester, at at 3 p.m.

BASIC BRICKS: Spinella, Saxpyre, Supermag, Diazite, Dolomax.

•

SILICA BRICKS: Lowood, Meltham, Allen, Quartex.

•

FIREBRICKS: Glenboig Special, Glenboig Special Crown, Glenboig, Glenboig Crown, Castlecary, Dykehead, Gem, White Carr, Stour, Hycone.

Alumantine, Hysilyn, Adamantine, Llangennech.

•

CEMENTS: Sintex, Durax, Pyrolyte.

•

INSULATION: Amberlite Bricks, Cement & Concrete.

•

SANDS: Moulding, Brick Facing, Silica, Glass.

•

PLASTICS: Durax, Rotaline, Plastic K-N, Glendoline, Ground Ganister.

•

SILLIMANITE: Tank Blocks, Bricks and Cements.

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ACID-PROOF REFRACTORIES: Obsidianite, Losol.

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Raw Material Markets

Iron and steel makers have such heavy orders on their books that the end of the year will undoubtedly be reached before many of these commitments have been cleared. Since the licensing scheme was introduced, consumers have quickly placed orders up to the limit of their allotments, and the present quarter has been no exception from this practice, buyers having negotiated up to December 31 in most instances. Consequently, new business for the time being is negligible. Makers' order-sheets are, in the main, filled with the specifications of works engaged on contracts in connection with Government requirements, but a certain amount of business is on hand for ordinary domestic users who have been able to acquire the necessary permits.

Pig-Iron

MIDDLESBROUGH—Ironmakers continue to be largely employed on the manufacture of iron needed by the steel plants, and the small output of Cleveland iron which becomes available is no real contribution to the satisfaction of the demands of local users of foundry numbers. Deliveries from the Midlands are arriving with commendable promptitude, and the only serious inconvenience of reliance upon this source of supply lies in the higher transport charges which are naturally involved. Now that the price of foundry iron has been further increased, extended use is being made of cast-iron scrap, which is fairly easy to obtain and is an economic proposition from a financial point of view. Fresh business in hematite is quite out of the question at the present juncture, local makers being heavily committed over the remainder of the year. Consumption is fully sustained, but importations have materially eased the supply situation, although further shipments are required. The needs of local steel plants are on a large scale, while as much attention as possible is being afforded to consumers in the Midlands and Sheffield.

LANCASHIRE—Continued brisk activity is reported among the speciality and other engineering establishments participating in defence contracts, and the demand for pig-iron from these concerns is absorbing large deliveries from Derbyshire and Northamptonshire furnaces. On the whole, satisfactory supplies have been forthcoming, but short delays are experienced from time to time. The position of the light-castings trade remains disquieting and many works are unable to operate their plant full time. Some jobbing foundries, too, are not receiving new orders as promptly as could be desired, although this branch is fairly steadily employed as yet. Some inconvenience is being caused by irregular deliveries of West Coast hematite, producers being able to meet only the most urgent demands without delays, which at times are quite lengthy in the case of less important orders.

MIDLANDS—Despite increased calls upon the output of high-phosphorus iron, all consumers are procuring adequate supplies. This iron is used chiefly by light-castings makers, but there has been quite a steady flow of deliveries during recent months to general engineers, who have been incorporating high-phosphorus iron in their mixtures owing to difficulty in getting sufficient tonnages of their usual grades. The position of the light-castings industry shows steady improvement, and if there is still much leeway to make up before works can operate to capacity, additional orders are coming to hand and the trend is undoubtedly in the right direction. Heavy engineers' activity is maintained, and replacement orders are forthcoming as soon as required. Foreign supplies of hematite and low-phosphorus iron are being used freely by these concerns, and continued recourse will have to be made to imported material for some time to come, as the home production is still very much below requirements.

SCOTLAND—Business with the iron consuming industries in this area remains brisk, with the exception of makers of light castings, who are not yet satisfactorily employed, despite the acquisition of further Government contracts. Their iron supplies are coming from the English Midlands quite freely on the basis of 126s. 9d., f.o.t. Falkirk, and 129s. 9d., f.o.t. Glasgow, both subject to 5s. per ton loyalty rebate. Heavy engineers, too, are obtaining satisfactory supplies of foundry iron, most of them being solely engaged on work of national importance, other consumers receiving only small tonnages.

Coke

Foundry coke distributors are despatching large tonnages to consumers, many of whom are building up substantial reserve stocks as a precaution against transport delays later. Export business has, of course, been at a greatly reduced level in recent months, but the strength of the inland market has been very gratifying and has absorbed a considerable proportion of the supplies which would normally have been shipped. For delivery to Birmingham and Black Country stations, the current price of Durham best foundry coke is 58s. per ton, but all new business is subject to payment at the rate ruling at the time of delivery.

Steel

There continues to be a wide demand for steel for use in connection with war requirements, and makers are fully booked up as far ahead as they care to go. Government departments are absorbing large quantities of various types of steel, and there appears to be no saturation point as yet to these orders, replacement contracts being available as soon as the producers can accept fresh bookings. If anything, there has been a slight easing in the demand for heavy joists and sectional steel, but this has not yet reached appreciable proportions, and there is still a ready market for all descriptions.

Scrap

Most grades of iron and steel scrap are sufficiently plentiful promptly to meet users' requirements; in fact, large stocks are on hand at many points, both dealers and consumers having more than they can deal with for the present. This comfortable state of affairs is likely to continue, but the collection of fresh tonnages is forging ahead, and the sorting and grading of new material is being carried out as promptly as when there was a shortage a few months ago. Foundry grades of scrap are being delivered in big tonnages, and there is ample material to meet all requirements.

Metals

Steady conditions have continued on the London tin market. As far as prices are concerned, it is improbable that there will be any marked fluctuation one way or the other for some time, although, if anything, the trend may be in an upward direction. Speculation on this point, however, is subject to various changes which may occur at any time in the existing circumstances.

A meeting of the International Tin Committee was due to be held on Tuesday last, but was postponed to a date which will be announced later in order to allow of the attendance of the Dutch delegation's representative, Mr. van den Broek.

It is understood that although the contract which the United States has concluded with Bolivian producers of tin ore and concentrates is for five years, the price basis has only been fixed up to the end of the first half of next year. During that period America will pay 48½ cents per lb. for the tin content of the ores, after which the price to be paid will be subject to further negotiation, although it is believed the U.S. Government has assured Bolivia of a minimum price of 40 cents per lb., at the same time stipulating a maximum figure of 60 cents.

London Metal Exchange tin prices this week have been as follow:—

Cash—Thursday, £257 15s. to £258; Friday, £258 5s. to £258 10s.; Monday, £258 5s. to £258 10s.; Tuesday, £258 to £258 5s.; Wednesday, £257 15s. to £258.

Three Months—Thursday, £259 15s. to £260; Friday, £260 to £260 5s.; Monday, £260 5s. to £260 10s.; Tuesday, £259 15s. to £260; Wednesday, £259 15s. to £260.

The copper situation in this country is unchanged, essential consumers being supplied with adequate tonnages. Only moderate tonnages can be released for other users in view of the very heavy consumption involved in war orders. American domestic sales of copper in the first nine months of the current year totalled 811,776 short tons, which is more than the turnover during the whole of 1939 (803,358 tons), while in 1938 sales over the twelve months were only 514,067 tons. Copper refining capacity in Canada is being taxed to its full extent, and it is estimated that of the current output of approximately 350,000 short tons more than 50,000 tons is being refined and some of it smelted in the United States.

Adequate deliveries of spelter are being made to firms on war contracts, while there is a moderate tonnage available for other important consumers. There is little restriction on the use of lead, which is in plentiful supply for all purposes.

London and South-Eastern Area Board

Readers directing industrial establishments or who are employed in the London area should, in case of any emergency caused through enemy action, contact with the technical officer—Eng. Capt. W. H. Pudner, at Brettenham House, Lancaster Place, W.C.2 (Phone, Temple Bar 9591, extension 17), or preferably with the district clearing centres. The technical officers in charge of each, their addresses and telephone numbers are:—

Central.—Mr. L. Pellat, Room 29, Romney House, Marsham Street, S.W.1 (Franklin 2211, extension 2680).

No. 1.—Mr. R. E. Allfrey, Equitable House, George street, Croydon, Surrey (Croydon 3946).

No. 2.—Mr. B. H. Auld, 60A, High Street, Acton, W.3 (Acorn 5984).

No. 3.—Mr. J. B. Taunton, 15, College Road, Harrow (Harrow 4586).

No. 4.—Mr. F. W. Churchard, 198, Fore Street, Edmonton, N.18 (Tottenham 3220).

No. 5.—Mr. L. J. Sargeant, Rooms 15 and 23, Cranbrook House, Cranbrook Road, Ilford, Essex (Ilford 1386).

No. 6.—Mr. C. J. Phillips, 20, Court Road, Eltham, S.E.9 (Eltham 5449). Temporary address: Dartford Iron Works, Dartford, Kent (Dartford 3456).

Rochester.—Mr. L. N. Whiteley, c/o Winget, Limited, Rochester, Kent (Strood 7276).

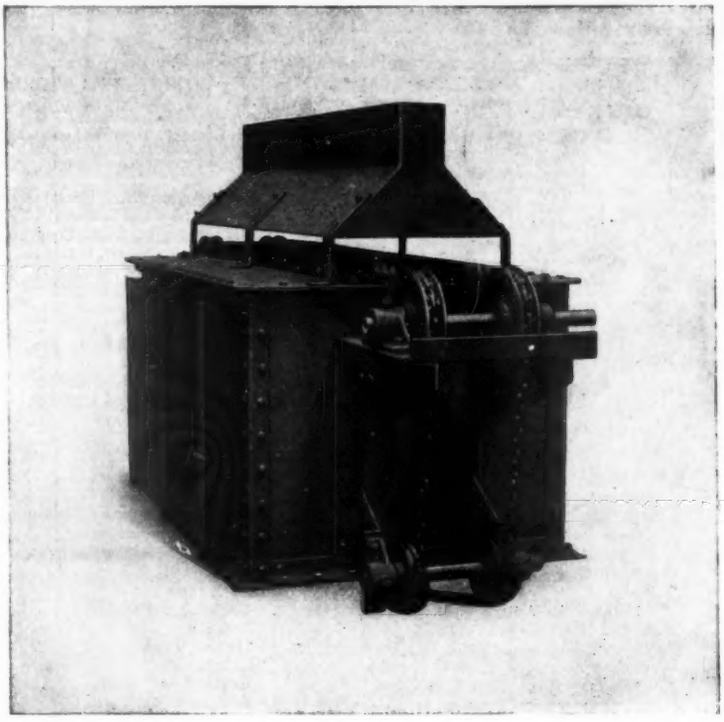
Sussex.—Mr. C. L. Sainty, Clayton Priory, Hassocks, Sussex (Bolney 342).

A Tower-Scaffold Accident

The Monthly Bulletin of the National Safety First Association makes reference to an accident involving a tower scaffold. Three men were at work on the platform of a wheeled tower scaffold 30 ft. high and with a wheel-base of 9 ft. 6 in. They were engaged in work on the underside of a roof when the scaffold overturned, causing the death of one man and injuries to the others. It appears that they were attempting to move the scaffold along in its normal direction of travel by pulling at the roof supports.

It will be noted that this particular scaffold was not very well designed because of the relation between the height and the length of the base. The ratio of height to wheel-base length was over three to one. In such circumstances it is obviously extremely dangerous to attempt to move a scaffold by applying force at the top, unless compensating weights are placed on the base.

The rule of one reputable maker of these scaffolds is to limit the height to twice the shorter base dimension and to place weights on the base equal to the weight of the men on the platform. Naturally, if heavy tools and materials have to be taken on to the platform, it might be desirable to provide additional weight at the base.



CONTINUOUS CHAIN FURNACE

FOR LOCAL HEATING, HEATING FOR JOGGLING FISHPLATES, etc., etc.

Illustration shows oil-fired furnace, but any type can be arranged to suit requirements.

FURNACES, STOVES, SAND PLANTS

SPECIALISTS

Latest design Mixers delivered from Stock

COGGON FOUNDRY EQUIPMENT LTD Ovenden HALIFAX

Phone: 2423 Halifax Grams: COGGON, HALIFAX

ON ADMIRALTY, WAR OFFICE, AIR MINISTRY, LLOYDS, AND OTHER APPROVED LISTS.

T. J. LLOYD & CO LTD

Specialists in

STEEL CASTINGS

From a few ounces up to **25 TONS**

FOR ALL INDUSTRIES

JAMES BRIDGE STEEL WORKS near WEDNESBURY ··

PHONE DARLASTON 225 (3 lines)
GRAMS STEEL DARLASTON

RAW MATERIALS—PRICE LIST

Wednesday, November 27, 1940

COPPER*

	£	s.	d.
Electrolytic	62	0	0
High-grade fire-refined	61	10	0
Fire-refined of not less than 99.7 per cent.	61	0	0
Do., do., 99.2 per cent.	60	10	0
Black hot-rolled wire rods	65	10	0

TIN

	£	s.	d.
Standard cash	257	15	0
Three months	259	15	0
Settlement	258	0	0
Official average Cash, Oct.	258	3	0 4/23
Do. Three Months, Oct.	260	10	3 21/23
Do. Settlement, Oct.	258	2	9 21/23

SPELTER*

	£	s.	d.
G.O.B. (foreign) (duty paid)	25	15	0
Do. (domestic)	26	10	0
"Prime Western"	26	10	0
Refined and electrolytic	27	5	0
Not less than 99.99 per cent.	28	15	0

LEAD*

	£	s.	d.
Good soft pig lead (foreign) (duty paid)	25	0	0
Do., do., (Empire and domestic)	25	0	0
English	26	10	0
Sheets, home	34	10	0
Do. export, f.o.b.	30	0	0
Pipes, home	34	0	0
Do. export, f.o.b.	30	10	0
Tea lead (nom.)		—	

ALUMINIUM

Ingots	£110
Wire, 10g.	nom.
Sheets	nom.
Circles, 20/24g.	nom.

ZINC SHEETS, etc.

	£	s.	d.
Sheets, 10g. and thicker, ex works	39	2	6
Rolled zinc (boiler plates), ex works	37	2	6
Zinc oxide (Red Seal), d/d buyers' premises	28	7	6

ANTIMONY

	£	s.	d.
English, 90%, delivered	90	0	0
Foreign Regulus, duty paid	90 0 0 to 93	0	0
Chinese, prompt shipment, c.i.f.	78 0 0 to 82	0	0

QUICKSILVER

Quicksilver, ex-w'hse London 49 0 0 to 52 0 0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten 3s. 0d.
Finished bars, 18% tungsten 3s. 10d.
Finished bars, 22% tungsten 4s. 4d.
Per lb. d/d buyers' works.

NICKEL SILVER, etc.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½

with extras according to gauge.

Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

* Maximum prices per long ton delivered to buyers' premises.

FERRO-ALLOYS AND STEEL-MAKING METALS

(all prices nominal.)

	£	s.	d.
Ferro-silicon (5-ton lots)—			
25%	18	10	0
45%	23	10	0
75%	36	10	0
Ferro-vanadium—			
35/50%	15/6 lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free	6/- lb. Mo.		
Ferro-titanium—			
20/25% carbon-free	1/9 lb.		
Ferro-tungsten—			
80/85%	5/1 lb.		
Tungsten metal powder—			
98/99%	5/2½ lb.		
Ferro-chrome—			
2/4% car.	—		
4/6% car.	47	0	0
6/8% car.	47	0	0
8/10% car.	—		
Ferro-chrome—			
Max. 2% car.	—		
Max. 1% car.	—		
Max. 0.5% car.	—		
70% carbon-free	—		
Nickel—99.5/100%	£190 to £195		
"F" nickel shot	175	0	0
Ferro-cobalt, 98/99%	8/9 lb.		
Metallic chromium—			
96/98%	3/9 lb.		
Ferro-manganese—			
76/80% loose	18	10	0
76/80% packed	20	0	0
Metallic manganese—			
94/96% carbon-free	1/9 lb.		

Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.

SCRAP*

	£	s.	d.	£	s.	d.
SOUTH WALES—						
Short heavy steel, not ex. 24-in. lengths	3	16	6	to 3	19	0
Heavy machinery cast iron				4	6	6
Ordinary heavy cast iron				4	1	6
Cast-iron railway chairs				4	6	6
Medium cast iron				3	17	9
Light cast iron				3	13	0
MIDDLESBROUGH—						
Short heavy steel	3	14	3	to 3	16	9
Heavy machinery cast iron				4	11	3
Ordinary heavy cast iron				4	8	9
Cast-iron railway chairs				4	8	9
Medium cast iron				3	19	0
Light cast iron				3	14	0
BIRMINGHAM DISTRICT—						
Short heavy steel	3	9	3	to 3	11	9
Hematite ingot mould				5	10	9
Heavy machinery cast iron				4	11	9
Ordinary heavy cast iron				4	7	0
Cast-iron railway chairs				4	7	0
Medium cast iron				3	19	9
Light cast iron				3	14	9
SCOTLAND—						
Short heavy steel	3	14	0	to 3	16	6
Heavy machinery cast iron				4	13	9
Ordinary heavy cast iron				4	8	9
Cast-iron railway chairs				4	13	9
Medium cast iron				3	16	9
Light cast iron				3	11	9

* Delivered free to consumers' works in England and Wales. For deliveries of cast-iron scrap free to consumers' works in Scotland, the above prices less 3s. per ton, but plus actual cost of transport or 6s. per ton, whichever is the less. All prices: Plus 2½ per cent. dealers' remuneration; 50 tons and upwards over three months 2s. 6d. extra.

PIG-IRON*

	£	s.	d.
N.E. COAST (d/d Tees-side area)—			
Foundry No. 1	131/-		
,, No. 3	128/-		
,, No. 4	127/-		
Forge No. 4	127/-		
Hematite No. 1	138/6		
Hematite M/Nos.	138/-		
N.W. COAST—			
Hem. M/Nos. d/d Glasgow	138/6		
,, d/d Birmingham	150/-		
MIDLANDS (d/d Birmingham dist.)—			
Staffs No. 4 forge	129/-		
,, No. 3 fdry.	130/-		
Northants forge	126/6		
,, fdry. No. 3	127/6		
,, fdry. No. 1	130/6		
Derbyshire forge	129/-		
,, fdry. No. 3	130/-		
,, fdry. No. 1	133/-		
Phosphorus 0.5% to 0.75%	137/6		
Phosphorus 0.1% to 0.5%	140/6		
SCOTLAND—			
Foundry No. 1, Grangemouth	127/3		
,, No. 3, Grangemouth	124/9		
Cleveland No. 3, Glasgow	131/-		
,, ,, Falkirk	128/-		
Scottish hem. M/Nos. d/d	138/6		
SHEFFIELD (d/d district)—			
Derby forge	126/6		
,, fdry. No. 3	127/6		
Lincs forge	126/6		
,, fdry. No. 3	127/6		
W.C. hematite	144/-		
LANCASHIRE (d/d eq. Man.)—			
Derby fdry. No. 3	133/-		
Staffs fdry. No. 3	133/-		
Northants fdry. No. 3	131/6		
Cleveland fdry. No. 3	133/-		
Cylinder and Refined Irons			
North Zone	174/-		
South Zone	176/6		
Refined Malleable			
Birmingham and S. Staffs	171/6		
Cold Blast			
South Staffs	220/6		

* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms and Slabs.

	£	s.	d.
BASIC:			
Soft, u.t., 100-ton lots	12	5	0
Tested, up to 0.25% C.	12	10	0
Tested, 0.25 to 0.33% C.	12	12	6
Tested, 0.33 to 0.41% C.	12	15	0
Hard (0.42 to 0.60% C.)	13	17	6
,, (0.61 to 0.85% C.)	14	7	6
,, (0.86 to 0.99% C.)	14	17	6
,, (1% C. and up)	15	7	6
Silico-manganese	16	5	0
Free-cutting	14	10	0
SIEMENS MARTIN ACID			
Up to 0.25% C.	15	15	0
Case-hardening	16	12	6
Silico-manganese	16	5	0

Billets, Blooms and Slabs for Forging and Stamping.

Basic soft, up to 0.25% C.	13	17	6
Basic hard, 0.41 to 0.60% C.	14	10	0
Acid, up to 0.25% C.	16	5	0

Other Semi-products, etc.

Tin bars	12	2	6
Sheet bars	12	2	6
*Wire rods, soft basic	17	7	6
,, hard basic	21	2	6
,, free-cutting	20	2	6
acid	24	13	

* Subject to rebate.

FINISHED STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel bars, sections, plates, joists and hoops is obtainable in the home trade under certain conditions.]

	£	s.	d.
Plates, ship (N.E. Coast)	16	3	0
Boiler plts. (N.E. Coast)	17	0	6
Chequer plts. (N.E. Coast)	17	13	0
Angles, over 4 un. ins.	15	8	0
Tees, over 4 un. ins.	16	8	0
Joists, 3 in. × 3 in. and up	15	8	0
Rounds and squares, 3 in. to 5½ in.	16	8	0
Rounds under 3 in. to ⅜ in. (untested)	17	12	0
Flats—over 5 in. wide	15	13	0
,, 5 in. wide and under	17	12	0
Rails, heavy, f.o.t.	14	10	6
Hoops	18	7	0
Black sheets, 24 g. (4 t. lots)	22	15	0
Galv. cor. shts. (,,)	26	2	6
Galv. flat shts. (,,)	26	12	6
Galv. fencing wire, 8g. plain	26	17	6

FINISHED IRON

	£	s.	d.
CROWN IRON:			
England and Wales	15	12	6
Scotland	15	12	6
Ireland, f.o.q.	16	5	0
No. 3 BARS:			
England and Wales	12	10	0
Scotland	13	12	6
Ireland, f.o.q.	13	2	6
No. 4 BARS:			
England and Wales	13	0	0
Scotland	13	17	6
Ireland, f.o.q.	13	12	6
STRIP:			
England and Wales	17	0	0
STAFFS MARKED BARS, f.o.t.	—		

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated, October 22, 1940.

	Dols.
No. 2 foundry, Phila.	24.84
No. 2 foundry, Valley	23.00
No. 2 foundry, Birm.	19.38
Basic, Valley	22.50
Malleable, Valley	23.00
Grey forge, Valley	22.50
Ferro-mang., seaboard	120.00
O.-h. rails, h'y, at mill	40.00
Billets	34.00
Sheet bars	34.00
	Cents
Iron bars, Chicago	2.25
Steel bars	2.15
Tank plates	2.10
Beams, etc.	2.10
Wire rods	2.00
Skelp, grooved steel	1.90
Steel strip	2.10
Steel sheets	2.10
Sheets, galv., 24 g.	3.50
Wire nails	2.55
Plain wire	2.60
Tinplates, 100-lb. box	$5.00

COKE (at ovens)

(nominal)

Welsh foundry	45/- to 46/6
,, furnace	34/- to 35/6
Durham foundry	42/-
,, furnace	35/6
Scottish foundry	45/- to 50/-
,, furnace	33/6 to 35/6

TINPLATES

(f.o.b Bristol Channel ports)

I.C. cokes	20 × 14 per box	30/9 to 32/-
,,	28 × 20 ,,	61/6 to 64/-
,,	20 × 10 ,,	44/3 to 44/9
,,	18¾ × 14 ,,	32/- to 32/6
C.W.	20 × 14 ,,	27/9 to 28/9
,,	28 × 20 ,,	55/6 to 57/6
,,	20 × 10 ,,	42/3 to 42/9
,,	18¾ × 14 ,,	30/- to 30/6

NON-FERROUS SCRAP

(Official Maximum Prices, per ton ex Works.)

	£	s.	d.
Bright untinned copper wire, in crucible form or in hanks	57	10	0
No. 1 copper wire	57	0	0
No. 2 copper wire	55	10	0
Copper firebox plates, cut up	57	10	0
Clear untinned copper, cut up	56	10	0
Braziery copper	53	10	0
Q.F. process and shell-case brass, 70/30 quality, free from primers	49	0	0
Clean fired 303 S.A. cartridge cases	47	0	0
70/30 turnings, clean and baled	43	0	0
Brass swarf, clean, free from iron and commercially dry	34	10	0
New brass rod ends, 60/40 quality	38	10	0
Hot stampings and fuse metal, 60/40 quality	38	10	0
Admiralty gunmetal, 88-10-2, containing not more than ½ per cent. lead or 3 per cent. zinc, or less than 9½ per cent. tin	72	0	0

NEW BRASS TUBES, etc.

	Per lb.
Solid drawn tubes	13½d.
Brazed tubes	15½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	8½d.
Sheets to 10 w.g.	10½d.
Wire	10½d.
Rolled metal	9½d.
Yellow metal rods	8½d.

COPPER TUBES, etc.

Solid drawn tubes	14½d.
Brazed tubes	14½d.
Wire	9½d.

PHOSPHOR BRONZE

	Per lb. basis
Strip	13½d.
Sheet to 10 w.g.	13½d.
Wire	15½d.
Rods	15½d.
Tubes	20½d.
Castings	17d.

Delivery 3 cwt. free.
10% phos. cop. £35 above B.S.
15% phos. cop. £40 above B.S.
Phosphor tin (5%) £40 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

A COMPARISON OF CAST-IRON SCRAP PRICES

Average Monthly Prices of Cast-iron Scrap in the Principal Districts in the Years 1934–40

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
SCOTLAND (Heavy Machinery)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1934..	2 14 2	2 17 9	2 18 5	2 18 3	2 15 5	2 15 9	2 14 3	2 15 0	2 15 9	2 15 0	2 15 8	2 16 3	2 16 0
1935..	2 15 5	2 15 8	2 15 10	2 16 4	2 16 10	2 17 0	2 16 9	2 16 9	2 17 0	2 16 11	3 2 7	3 2 7	2 17 5
1936..	3 4 8	3 9 10	3 10 11	3 11 10	3 10 8	3 9 10	3 9 2	3 8 9	3 8 11	3 9 2	3 10 0	3 13 3	3 9 9
1937..	3 15 0	4 2 10	4 6 2	4 9 9	4 14 9	4 15 0	4 15 0	4 15 0	4 15 0	4 15 6	4 15 0	4 13 3	4 11 0
1938..	4 11 3	4 11 3	4 8 3	4 5 7	4 1 2	3 17 10	3 15 0	3 14 4	3 12 7	3 14 10	3 18 0	3 18 0	4 0 8
1939..	3 19 0	3 19 0	3 19 0	3 19 0	4 1 1	4 2 6	4 2 6	4 3 2	4 5 5	4 3 0	4 3 0	4 3 0	4 1 8
1940..	4 3 0	4 3 0	4 13 0	4 13 0	4 13 7	4 13 9	4 13 9	4 13 9	4 13 9	4 13 9	4 13 9	—	—
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
N.E. COAST (Heavy Qualities)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1934..	2 12 7	2 15 1	2 13 7	2 11 6	2 11 11	2 13 9	2 11 0	2 10 6	2 11 3	2 11 10	2 13 9	2 13 3	2 12 4
1935..	2 12 2	2 13 0	2 12 7	2 13 0	2 12 9	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 16 10	2 12 10
1936..	3 0 0	3 1 10	3 1 8	3 2 2	3 4 6	3 3 9	3 5 9	3 4 1	3 5 11	3 6 3	3 6 3	3 7 10	3 4 2
1937..	3 10 6	3 14 9	4 2 6	4 3 9	4 6 3	4 7 6	4 7 6	4 7 6	4 6 0	4 5 0	4 5 0	4 5 0	4 3 5
1938..	4 5 0	4 2 6	4 0 0	3 18 1	3 11 3	3 10 0	3 10 0	3 9 8	3 11 0	3 13 1	3 15 0	3 13 6	3 14 11
1939..	4 0 0	4 0 0	4 0 0	4 0 0	4 2 6	4 1 6	4 0 0	4 0 0	4 0 2	4 0 6	4 0 6	4 0 6	4 0 6
1940..	4 0 6	4 0 6	4 10 6	4 10 6	4 11 1	4 11 3	4 11 3	4 11 3	4 11 3	4 11 3	4 11 3	—	—
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
S. WALES (Heavy Cast Iron)—	£ s. d	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1934..	2 6 10	2 8 9	2 7 8	2 6 6	2 7 6	2 8 0	2 6 10	2 6 7	2 8 0	2 8 2	2 9 1	2 11 5	2 7 1
1935..	2 11 3	2 11 4	2 11 1	2 11 3	2 12 0	2 11 1	2 11 1	2 11 0	2 12 2	2 13 10	2 14 5	2 14 8	2 11 9
1936..	2 16 3	2 18 7	2 18 9	2 19 2	2 18 7	2 18 7	2 19 0	2 19 0	2 18 9	2 19 0	2 19 2	2 19 0	2 18 8
1937..	3 4 1	3 9 8	3 9 3	3 9 0	3 9 0	3 9 0	3 9 0	3 9 0	3 8 9	3 9 9	3 9 9	3 9 11	3 8 10
1938..	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 9
1939..	3 1 6	3 1 6	3 1 6	3 1 6	3 1 6	3 1 6	3 1 6	3 1 6	3 3 5	3 9 0	3 9 0	3 9 0	3 3 7
1940..	3 9 0	3 9 0	3 19 0	3 19 0	3 19 7	3 19 9	3 19 9	3 19 9	3 19 9	3 19 9	3 19 9	—	—

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